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HARVESTS AND MANAGEMENT OF WARM-WATER FISH POPULATIONS IN MASSACHUSETTS' LAKES, PONDS, AND RESERVOIRS

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and
Harold Bitzer, Division of Fisheries and Game, Upton, Massachusetts

A STUDY OF ANGLER-HARVEST OF WARM-WATER GAME AND PAN FISHES was initiated in September 1950. Virtually no such information was available for the Northeastern States. Except for black basses, little tagging of species common to Massachusetts appears to be on record. Factors contributing to this lack of basic management information have included disinterest, distrust of existing tags, and reluctance to alter the status quo.

Knowledge of harvest rates of important sport fish species is important to sound fishery management. Habits of anglers are revealed. Along with findings from population studies, such knowledge may point to causes of poor fishing and indicate possible solutions.

In Massachusetts, tag returns have shown that anglers take relatively large numbers of the predatory game fishes. Unpublished population studies have revealed, in turn, that these important fish make up relatively small fractions of available fish crops. Some pan fishes go virtually untouched. Others are barely exploited, though they constitute the vast majority of fish available to anglers.

The findings have suggested that some species are both more vulnerable to angling and more sought-after than others. The findings have revealed the need for research and education programs designed to assist the angler to catch more of certain kinds of fish, particularly pan fishes. They have shown that few catchable-size game and pan fish migrate from the lakes and ponds. They have also revealed the exorbitant costs of improving fishing by stocking catchable warm-water fishes.

To date, as a result, regulations that restrict harvests of pan fishes have been greatly liberalized. Earlier recommendations for the screening of outlets at many warm-water ponds (McCabe 1948) have been abandoned. Salvage activities for the purposes of maintenance stocking and "supplementing brood stock" have been curtailed. Extensive population control is under way (Stroud 1952).

The Fish Involved

Altogether, 8,038 game fish and 4,940 pan fish -- 12,978 fish in all -- were tagged and released in the 3-year period from September 1950 through October 1953 (table 1). These fish were released in

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Mr. Stroud was formerly Chief Aquatic Biologist, Massachusetts Division of Fisheries and Game. He initiated and directed this study, wrote the paper, and assumes responsibility for any misinterpretation of the data.

Mr. Bitzer was responsible for, and directly supervised, most of the actual field work.

Carleton Hudson, Michael Miskewich, James Mullan, and Mrs. Ralph Woolner contributed substantially to the study.

Photographs were made by Daniel Grice.

TABLE 1.--Game and pan fishes tagged and released in 107 Massachusetts lakes, ponds, and reservoirs, September 1950 to October 1953, inclusive

Species	Number of waters	Native fish (number)	Salvaged fish (number)	Total number of fish
Largemouth bass, Micropterus salmoides-----	21	45	804	849
Smallmouth bass, Micropterus dolomieu------	43	674	3,275	3,949
Chain pickerel, Esox niger----------	65	1,102	2,138	3,240
Brown bullhead, Ameiurus nebulosus---------	15	1,278	532	1,810
White perch, Morone americana----------	12	270	422	692
Yellow perch, Perca flavescens----------	28	1,460	978	2,438
Totals----------	1/ 107	4,829	8,149	12,978

1/ Allows for the planting of more than one species in a number of ponds.

107 ponds that covered about 18,750 acres of surface area, or at the rate of about 2 tagged fish for each 3 acres (average, 2/3 fish per acre).

Largemouth bass, smallmouth bass, and chain pickerel, as listed in table 1, were jaw-tagged with No. 3 strap tags. Brown bullheads, white perch, and yellow perch, as listed in table 1, were cheek-tagged (Stroud 1953).

Only black basses 9.5 inches and up, pickerel 13.5 inches and up, and panfishes 8.0 inches and up were tagged; so all fish were of both legal and desirable sizes. Some were "native," being caught in fyke nets, tagged, and released in the ponds concerned. The remainder were "salvaged," being taken from closed water supplies by drainage or netting, tagged, and transferred to other waters open to public fishing. The size of each group is shown in table 1.

Tagging and Tag Recovery

Strap tags were attached, unrounded, around the maxillary and premaxillary bones together on black basses. On pickerel these tags were clinched, also unrounded, near the end of the snout around the outer row of palatine teeth and the maxillary together (figure 1). Cheek tags were attached to the preopercle area on bullheads and on white and yellow perches (figure 2). Attachment was by means of semiautomatic tagging pliers, substantially as described by Cable (1950).

Records of tag recoveries were gotten principally through voluntary mailings by anglers. Returns by mail were stimulated by frequent newspaper publicity and by posting individual waters liberally. As many as 35 posters were used at some ponds to cover likely points of access. Conservation officers and wildlife district managers often collected or verified information on captures of tagged fish. Often, one or more anglers living at ponds involved in this work assumed personal responsibility for collecting and forwarding the desired information.

Each poster and tag bore an address for the Division of Fisheries and Game that was unfamiliar to most anglers. Its exact duplication on virtually all correspondence about recovered tags attests to the success of the field advertising. Each report was acknowledged, and any questions were carefully answered.

A reward system and partial creel census were instituted at two ponds. A $1 item of fishing tackle was awarded by the Berkshire County League of Sportsmen's Clubs for each tag reported, and a monthly lottery was held for prizes of greater value. This circumstance affords a limited estimate of efficiency of voluntary tag returns.

Evidence for Reliability of Tags

The limited empirical and experimental evidence for reliability of these tags as employed here on these species was discussed earlier (Stroud 1953). Briefly, in year-long tests in drainable ponds, both cheek and jaw tags appeared to remain securely in place. It was not certain whether they exerted a significant influence on growth in this time.

As of this writing, too, 44 pickerel (3 percent of 1,460 available more than a year) have been recovered from 13 to 33-1/2 months since tagging. And, through June 1954, a total of 182 smallmouths (8.5 percent of 2,148 available) have been recovered from 1 to 3 years after tagging. Only 24 of these were taken by anglers--as much as 27 months later; the remainder were recovered in fyke nets--as much as 36 months at liberty.

Known angler recoveries of pan fish more than a year after tagging number only 2 bullheads (0.4 percent of 657 available). Recoveries of bullheads and yellow perch in fyke nets, however, have been as high as 21 percent in individual waters. The dearth of angler recoveries is therefore believed to reflect low harvest with considerable validity.

Effectiveness of Voluntary Reporting

The highest known annual recoveries were made from 301 native pickerel tagged during the fall at Cheshire Reservoir and at Stockbridge Bowl, Berkshire County. The actual recoveries--59 and 52 percent, respectively--were made under conditions of prolonged ice cover, partial creel census, and reward stimulus. Subsequent recoveries boosted the known totals to 60 and 55 percent. No doubt a few recovered tags went unnoted, so only 95 percent efficiency in the reporting of recovered tags was assigned here to account for this likelihood. Consequently, with this estimated correction, maximum annual pickerel harvest (mostly through the ice) probably ranged between 55 and 62 percent during the study.

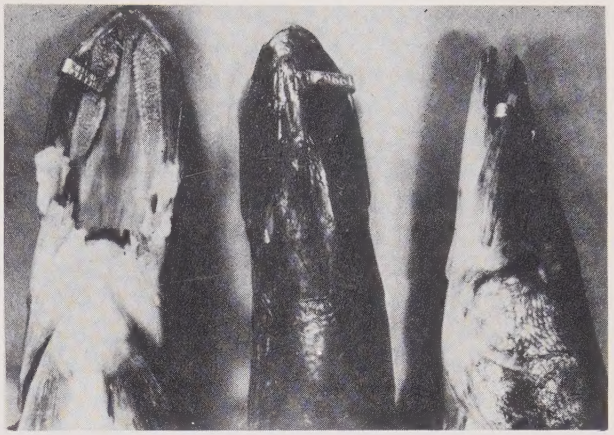

FIGURE 1.--Strap tag attached unrounded to snout of chain pickerel, showing method of clinching around maxillary and outer palatine tooth plate. From left to right: bottom view with lower jaw removed; top view; and side view.

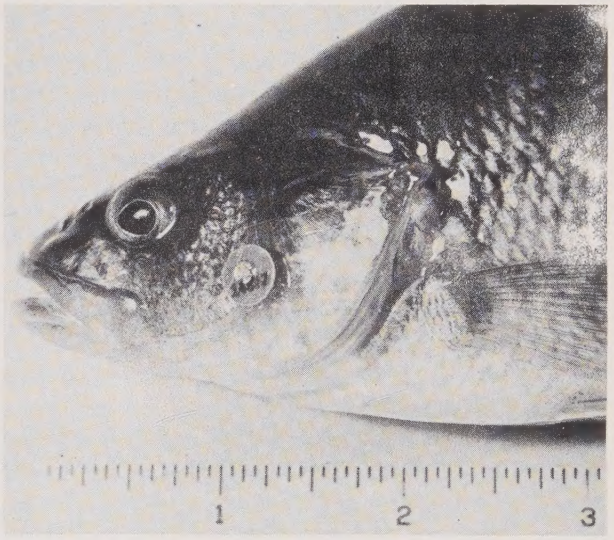

FIGURE 2.--Head of yellow perch with cheek tag attached in the preopercle area.

(Photographs courtesy Massachusetts Division of Fisheries and Game)

The next highest known annual recoveries of fall-tagged pickerel were from 148 salvaged fish that had been stocked at Duck Pond (46 fish), Middlesex County,

and at Massapoag (45 fish) and Nipmuck (57 fish) Ponds, Worcester County. The recoveries--48, 42, and 40 percent, respectively--were made without benefit of censusing or rewards, and with less ice. More intensive angling on these waters may compensate somewhat for less ice. The highest of these harvests was at Duck Pond in the second winter after tagging, rather than in the first.

Without allowance for possible selective mortality, the highest known returns from voluntary reporting, therefore, were about three-fourths of the maximum known harvest when returns were virtually complete. Applied to the three ponds identified above, the estimated harvests would be 64, 56, and 53 percent, respectively.

It is assumed that this is a reasonable estimate of the efficiency of the voluntary reporting of recoveries. This can be neither proved nor disproved. It merely represents the senior author's best estimate. There was no reason for tags from other species to be reported either more or less readily than those from pickerel. Therefore, all estimates of actual harvest are based on an expansion of known tag returns by 1-1/3 to account for unreported but recovered tags at this assumed level of efficiency for voluntary reporting of tags.

Harvests of Native Fish

Recoveries of native fish provided the most reliable index to rates of harvest by anglers. They were uninfluenced by selective mortality resulting from variable factors inherent in the salvage operation, from changes in chemical characteristics of the water, and other conditions. Indeed, estimation of mortality induced among salvaged fish is made by comparing tag recoveries from salvaged fish with tag recoveries from native fish.

Known Recoveries. --All told, 19 percent of game fish and 3 percent of pan fish were reported recovered by anglers (table 2). Ninety-one percent of the recoveries were made during the first year, 8 percent the second year, and 1 percent the third year after tagging.

A wide range in rate of recovery of each species was recorded among the ponds where the fish were tagged (table 3). Among largemouths, only the over-all average harvest of 9 percent has significance; too few were involved per pond (10 ponds) to warrant separate consideration. The highest significant harvest of native smallmouths occurred at Chauncey Pond, where 20 percent of 39 bass were reported recovered.

High recoveries of pickerel at 2 ponds are particularly significant. The 28-percent recovery at Cheshire Reservoir represents the average of recoveries from 4 separate lots tagged in successive fall and spring periods from October 1950 to October 1953. Known recoveries ranged from 15 percent of 131 fish tagged in spring to 60 percent of 126 fish tagged in fall. The 54-percent recovery noted at Stockbridge Bowl is the average of recoveries from 2 lots of fish tagged in successive fall periods. Here, recoveries were 53 and 55 percent of 88 fish and 87 fish tagged in October 1950 and October 1951, respectively.

The 10-percent known harvest of bullheads at Massapoag Pond was twice the next heaviest exploitation (Stockbridge Bowl) and 10 times that noted elsewhere. Yellow perch showed similar variability with greatest usage evident at Bare Hill Pond and Stockbridge Bowl, where at least 8 percent were taken. In addition, there were 5 ponds with 270 tagged white perch available for capture. Recoveries were made at only 1 pond (Chauncey) and they amounted to only 5 percent of the 58 fish that were tagged there.

Judging by the extremely variable harvests from pond to pond, it may be concluded, for one thing, that pond popularity varies widely. No doubt, accessibility is a key factor in popularity--and exploitation of fish populations for recreation.

Winter Fishing and Summer Fishing. --Most recoveries, except for pickerel, were made on open water. Pickerel and yellow perch are readily taken through the ice. Use of artificial lures (jiggers) for ice fishing, particularly effective with yellow perch, was illegal during the study.

TABLE 2.--Recoveries from 4,829 native game and pan fishes tagged and released in 15 Massachusetts lakes, ponds, and reservoirs, September 1950 to October 1953, inclusive

Species	Number of waters	Number tagged	Number of fish recovered				Known percent recovered[1]	Estimated percent harvested
			First season	Second season	Third season	Total		
Largemouth bass	10	45	4	------	------	4	9	12
Smallmouth bass	10	674	60	6	1	67	10	13
Chain pickerel	12	1,102	266	18	3	287	26	35
Brown bullheads	5	1,278	27	2	------	29	3	4
White perch----	4	270	3	------	------	3	1	1
Yellow perch---	7	1,460	29	7	------	36	3	4
Total or average-----	[2] 15	4,829	389	33	4	426	9	12

[1] Nearest whole percentum; cf. text for details of estimating total harvest.
[2] Total allows for plants of more than one species in a number of ponds.

TABLE 3.--Percentage of tagged native fish, by species, recovered at 14 ponds, with the total number of fish tagged at each pond shown in parentheses

Name of pond	County	Smallmouth bass	Chain pickerel	Brown bullhead	Yellow perch
Bare Hill----------	Middlesex	11 (63)	15 (20)	----------	8 (65)
Billington Sea------	Plymouth	0 (12)	9 (55)	----------	---------
Cedar Meadow--------	Worcester	10 (49)	25 (4)	----------	---------
Chauncey----------	Worcester	20 (39)	25 (4)	----------	---------
Cheshire----------	Berkshire	----------	28 (522)	1 (530)	3 (596)
Forge----------	Middlesex	10 (10)	----------	----------	---------
Indian----------	Worcester	----------	33 (12)	----------	---------
Lashaway----------	Worcester	2 (45)	----------	1 (342)	5 (46)
Long----------	Plymouth	----------	2 (162)	0 (77)	1 (524)
Massapoag----------	Norfolk	10 (379)	30 (87)	10 (133)	5 (63)
Norwich----------	Hampshire	5 (39)	0 (2)	----------	---------
Pontoosuc----------	Berkshire	----------	6 (50)	----------	---------
Quabbin----------	Worcester	10 (32)	0 (9)	----------	0 (17)
Stockbridge Bowl----	Berkshire	50 (6)	54 (175)	5 (196)	8 (149)
Average (Total)----------		10 (674)	26 (1,102)	3 (1,278)	3 (1,460)

The restriction greatly influenced fishing effort for yellow perch. Only 25 percent of perch recoveries were made during winter. Repeal of the law (1953) should provide increased fishing for yellow perch.

Winter fishing accounted for 78 percent of known recaptures of pickerel. About half of the pickerel were tagged 1 to 2 months before freeze-up; 72 percent of the recaptures were taken, through the ice, within 4 or 5 months. The other half of the pickerel were tagged during April or May; 71 percent of those recaptured were also taken within a few months--by open-water anglers. Most striking, however, is the fact that only 12 percent of spring-tagged pickerel were known to have been harvested, whereas at least 37 percent of fall-tagged pickerel were taken. It would appear that pickerel are simply

harder to catch in summer--even when available in relatively large numbers.

Observations of fishing at Cheshire Reservoir bear this out. In the fall of 1950, 126 pickerel were tagged; 59 percent were harvested the first winter. One year later (fall of 1951), 90 more were tagged; the ensuing ice cover was unsafe most of the season, and only 13 percent were harvested. Despite the low winter harvest, none of them were taken during the following summer. Only 4 percent more were reported the second winter. In the spring of 1952, 121 more pickerel were tagged. Catchable pickerel were available to summer anglers in abundance, but they harvested only 7 percent of these fish. However, after freeze-up, 9 to 10 months after tagging, another 7 percent were taken. At the same time, at least 22 percent of 96 more pickerel that were tagged shortly before this freeze-up (fall of 1952) were harvested.

It is concluded that annual natural mortality of chain pickerel is rapid. If many of the fish present at any given time are not harvested that same season, they probably will not survive in sufficient number to contribute substantially to the fishing at another season. If the pickerel are not harvested in winter, they do not result in appreciably improved fishing in summer.

Nevertheless, a few big fish, in the 18- to 24-inch class, that are taken annually in the sport fishery are made possible by the small percentage of the fish which, available at any season, survive to later seasons. This is undoubtedly cumulative in effect to some extent. The quality of the fishery for the future, however, appears to depend primarily on detection and control of environmental factors--overcrowding by pan fishes that compete with and prey on young pickerel is suggested as one of them--that limit survival of juvenile pickerel, rather than on further restriction on the angler's harvest. A naturally caused restriction (inadequate ice cover) on harvest, beginning in 1951 at Cheshire, had failed to influence the quality of the fishing noticeably by the end of 3 years.

Estimated Harvest. --Correction for an efficiency of about 75 percent in voluntary reporting of recovered tags gave the estimates of harvest by anglers in this study (table 2). According to this calculation, 23 percent of the game fish and 4 percent of the pan fish were harvested.

Catchability

Game fishes appear superficially to be harvested about six times as readily as pan fishes. On the face of it, this seems unbelievable.

Much of the difference may be due to the fact that many anglers fish in shallow water at or near some visible cover, as weed beds, stumps, logs, and boulders, where game species are often found. It takes time and patience (i.e., it is more difficult) to locate schools of large pan fish in deeper water over invisible points of concentration.

It is also evident that part of the difference results from deliberate selection by anglers. In a recent economic survey of hunting and fishing in Massachusetts (Couture 1954), anglers were asked which species they fished for (not which they caught) on their trips. The answers indicated this distribution of angling effort: trout, 24.0 percent; black bass, 23.9 percent; pickerel, 19.4 percent; yellow perch, 11.0 percent, bullheads, 10.5 percent; white perch, 4.0 percent; all other species, 7.2 percent. From this it would seem that most fishing effort is directed toward catching game fish.

Among game fishes, bass were least readily recovered. On the average, pickerel were nearly three times as easy to take as bass. These findings merely suggest again that bass are wary fish.

Next to trout, pickerel are undoubtedly one of the easiest of fishes to harvest--especially in winter. They are easily taken through the ice with the crudest kind of tackle and tactics. Patience is the main ingredient for success.

Skill is seemingly more important when fishing for white perch, and few are caught. Too, little effort is made to catch them. Perhaps the chief drawback is

inability to locate perch schools. Yellow perch were taken about four times as often. They should be caught even more readily in future because of the ease with which yellow perch schools are located under the ice. Bullheads were about as easy to take as yellow perch.

The Role of Salvaged Fish

Salvaged fish were tagged so that it would be possible to estimate the extent of mortality from handling or stocking, their rate of utilization by anglers, and the cost feasibility of providing additional fishing through salvage and transfer. Mortality from the salvage and transfer activities loomed as a big question. It proved to be extensive, at least among bass, pickerel, and -- less certainly -- among yellow perch and white perch, too. Bullheads probably survived the best.

Mortality From Stocking. --Selective mortality among stocked fish cannot be due to the specific act of tagging, as this should affect native fish in equal proportion--but doesn't. Taken collectively, selective mortality seems to affect from 30 to 50 percent of all fish salvaged. Individual cases, especially as inferred from comparative tag returns, might be questioned. Taken collectively, however, the evidence is hardly deniable.

Direct evidence of mortality was observed on the shorelines of several ponds within a few days after stocking. At one pond, 10 out of 54 planted yellow perch were found dead a few days after stocking. No recoveries by anglers were ever reported here. It seems reasonable to assume that fairly complete mortality prevailed.

Plants totaling 439 smallmouths were made in 2 ponds, and their shorelines were inspected periodically for a week afterwards. Altogether, 55 (16 percent) out of 350 planted at 1 pond were found dead. Nevertheless, at least 4 percent of the possible survivors were taken by anglers up to 12 months later, and nearly 4 percent more were taken in fyke nets about 2 years after stocking. On the other hand, no recoveries were ever known from 89 bass released in another pond. Here, 64 of them (72 percent) were found dead within a few days. Interestingly, a second but "successful" plant of 112 smallmouths was made at this same pond only 2 days later. None was found dead. Anglers recovered at least 13 percent (14 fish)--all but 2 of these fish caught 9 to 16 months after release.

By species, no recoveries were ever reported for these plants of salvaged fish: 383 smallmouths at 10 ponds, 25 largemouths at 2 ponds, 314 pickerel at 19 ponds, and 187 perch at 7 ponds. More or less complete mortality was assumed for these plants. They were not included in the estimates of minimum harvest.

It is very likely, too, that partial mortality affected many other plants, though no dead fish were found or reported. For example, 2 lots of smallmouths (93 fish and 105 fish) were stocked at popular Goose Pond, Berkshire County. Recovery from the first lot was at least 27 percent. Only 2 percent were reported from the second lot. Similar cases are known.

Returns from both bullheads and white perch were too low to lend significance to lack of returns from particular lots.

Estimated Smallmouth Mortality. --An estimate of partial mortality among salvaged smallmouths was secured at Massapoag Pond, Norfolk County. Intensive reduction of suckers was initiated there in May 1953 with modified fyke nets. During operations, 379 native smallmouth bass were caught, tagged, and released again. About 3 weeks later, 200 salvaged smallmouths were tagged and released there, also.

In the following year, 38 native (9.8 percent) and 13 salvaged (6.5 percent) smallmouths were reported taken by the anglers. Assuming equal catchability of native and salvaged bass, one-third of the latter may have died soon after release.

Netting operations were resumed in May 1954. Discounting only known recoveries, no more than 341 tagged native and 187 tagged salvaged bass were present. Of these, 109 (32.0 percent) native and 37 (19.8 percent) salvaged bass were recaptured in the fyke nets.

Again, assuming that survivors of both groups were equally catchable (this time by fyke nets), it may be concluded that about one-third (38 percent from the netting data) of the salvaged bass died soon after stocking.

Another experience is interesting in this connection. The maximum known harvests of smallmouths were made from salvaged lots of 130 fish (1951) and 143 fish (1952) stocked at Stockbridge Bowl. They yielded known recoveries of 58 and 39 percent; estimated total recoveries were about 61 and 41 percent, respectively. If one-third of the 1952 fish died shortly after their release, the survivors would have numbered 95, and the known harvest would have been 59 percent--about the same as in 1951. Fishing pressure was probably no less in 1952 than in 1951; native chain pickerel were harvested here at about equal rates in each of 2 successive years (1950, 1951). Some factor other than changes in fishing pressure--probably mortality--must have caused the apparent decrease in harvest.

Estimated Pickerel Mortality. --While most bass were taken in fyke nets in the spring or early in fall, most pickerel were gotten from draining ponds early in winter. Under these conditions, pickerel for tagging were subject to rougher handling. Many pickerel had to be discarded because they seemed fatally weakened.

Most of the evidence concerning mortality comes indirectly from tag returns. There were 608 natives tagged during fall in 4 ponds; they yielded at least 37 percent recoveries. There were 1,602 fall-tagged salvaged pickerel planted in 27 ponds;[1] known recoveries amounted to 19 percent.

About half of these fall-stocked salvaged pickerel seem to have died soon after stocking--if the comparative returns noted above are significant in this regard. It is believed that they are, taken collectively, though any individual case might be subject to doubt.

Returns from spring-tagged native and salvaged pickerel are more nearly alike. There were 533 native pickerel tagged during spring in 10 ponds; 12 percent were reported taken by anglers. There were 208 spring-tagged salvaged pickerel planted in 13 ponds;[2] 15 percent were definitely caught back. Selective mortality is less evident among these spring-tagged fish.

Estimated Pan Fish Mortality. --Experience has shown that the bullheads are extremely hardy fish. Some bullheads that were badly injured when released were recaptured several months later by anglers (Stroud 1953). It is believed that most bullheads survived being salvaged and that little selective mortality ever resulted.

Both white perch and yellow perch, however, have proved difficult to handle and move without the occurrence of a lot of mortality. Many perch commonly die en route to their destinations; many others are too weak to be planted upon arrival with any expectation of survival. It is believed that mortality among plants of these two species, as a result of salvage, is at least as great as the mortality among smallmouths--about one-third.

Estimated Utilization. --The following corrections were applied to the tagging and recovery data of all salvaged fish in estimating their actual harvest: (1) All fish found dead on shore after release (smallmouths and yellow perch) were excluded; (2) all plants of bass, pickerel, and yellow perch yielding no returns were excluded; (3) numbers of remaining tagged bass and perch available were reduced by 1/3; (4) numbers of fall-tagged pickerel left available were reduced by 1/2; and (5) all known recoveries were expanded 1-1/3 times to correct for 75 percent efficiency that was estimated above for return of recovered tags (except that tag recoveries of smallmouths at Stockbridge Bowl were considered 95 percent complete).

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[1] This excludes 206 fish in 8 ponds which yielded no returns and for which complete mortality was assumed.

[2] This excludes 122 fish in 12 ponds which yielded no returns and for which complete mortality was assumed.

In this manner, average harvest rates were calculated for salvaged fish estimated available to anglers (table 4).

Exceptionally high harvests were experienced occasionally for each species except white perch (never more than 1 percent). A few examples, especially for pickerel, have already been cited. As a rule, it seems fairly reasonable to assume that little selective mortality occurred among the lots of fish involved. Even so, the figures exceed the other harvests by wide margins. After expansion of known returns by one-third to account for unreported recoveries, some apparently high rates of harvest were noted, as related below.

Anglers took about 23 and 28 percent of available tagged largemouths at 2 ponds, much more than at any other waters. As cited earlier, the highest smallmouth harvest amounted to about 61 percent. By far the next highest harvests of this species were about 28, 35, 36, 37, and 39 percent. Maximum harvests of salvaged pickerel--53, 56, and 64 percent--have already been mentioned. Bullhead usage was never startling; it amounted to 11, 12, and 16 percent at the 3 high ponds. However, yellow perch exploitation did prove surprising at 2 ponds where takes of 35 and 36 percent were estimated. But, perch harvests elsewhere were no more than half this much--and more often were much less.[3/]

3/ Tagged fish available for capture at each pond (county) in the examples cited in this paragraph: largemouth--36 at Fosters Pond (Essex), 14 at Stiles Reservoir (Worcester); smallmouth--130 at Stockbridge Bowl (Berkshire), 68 at Mashpee-Wakeby Pond (Barnstable), 35 at Beck Pond (Essex), 93 at Goose Pond (Berkshire), 36 at Snows Pond (Plymouth), 77 at Seymour Pond (Barnstable); pickerel--57 at Nipmuck Pond (Worcester), 45 at Massapoag Pond (Worcester), 46 at Duck Pond (Middlesex); bullhead--50 at Big Pond (Berkshire), 100 at Otis Reservoir (Berkshire), 98 at Sugden Reservoir (Worcester); yellow perch--47 at Island Creek Pond (Plymouth) and 37 at Hastings Pond (Franklin).

Economics of Salvage. --Any realistic appraiser of salvage must consider costs in the light of angler-utilization. The personnel assigned to salvage the fish had to spend at least April, May, and November or December (or equivalent) at salvage work. This included the drainage of culture ponds, netting in water supplies, maintenance of equipment, and other work. It seems entirely reasonable to prorate all costs for one-fourth of a year, accordingly, to render a rough estimate of costs per pound of fish in the creel resulting from such a stocking program.

Altogether, in fiscal year 1952-53, about 1,700 pounds of harvestable pan fish and 4,000 pounds of harvestable game fish (about 960 pounds of largemouths, 1,330 pounds of pickerel, and 1,710 pounds of smallmouths) were secured for stocking by salvage (Mass. Div. Fish. Game 1953). This required one-fourth of the year's work and budget for the pond management program. The year's expenditures in this budget totaled about $57,000. Only about $40,000, however, was used for the entire year's activities of the "salvage personnel." The remainder was spent for other related activities. The costs of general administration and supervision--which any real accounting must include--are not included in the same budget account or in this rough estimate. The figure is conservatively low.

Roughly, then, it cost in excess of $10,000 to net and stock 5,700 pounds of catchable warm-water game and pan fish. As has been shown, at least one-third of these salvaged stocks undoubtedly died within a few days after being released, leaving no more than 3,800 pounds available to anglers. About 29 percent of the game fish (773 pounds) may have been harvested. About 9 percent of the pan fish (102 pounds) may have been harvested. Thus, about 875 pounds of fish may have reached the anglers' creels as a result of 3 months' work by 2 salvage crews.

On this basis, it is roughly estimated that the fishing-license buyers paid well over $11 for each pound of fish taken. Though a fraction of the cost of producing an equivalent harvest of catchables in

TABLE 4.--Estimated rates of utilization of 8,149 salvaged game and pan fishes tagged and released in 97 Massachusetts lakes, ponds, and reservoirs, September 1950 to October 1953, inclusive

Species	Number of waters	Number of fish	Post-release losses[1]			Estimated number of survivors	Number of known angler recoveries	Estimated total angler recoveries[1]	Estimated rate of utilization (percent)[2]
			Found dead	"Complete" mortality	Partial mortality				
Largemouth bass	11	804	-----	25	260	519	43	57	11
Smallmouth bass	43	3,275	119	383	924	1,849	382	473	26
Chain pickerel	65	2,138	-----	314	801	1,023	340	453	44
Brown bullhead	10	532	-----	----------	---------	532	25	33	6
White perch	8	422	-----	----------	141	281	2	3	1
Yellow perch	21	978	10	187	260	521	65	87	17
Total or average	97[3]	8,149	129	909	2,386	4,725	857	1,106	23

1/ See text for details.
2/ Nearest whole percentum.
3/ Allows for the planting of more than one species in a number of ponds.

established populations through a program of maintenance stocking with hatchery-raised fingerlings, the cost is obviously prohibitive.

Migration to Other Waters

Installation of outlet screens to prevent loss of warm-water game fish has been recommended for many Massachusetts lakes, ponds, and reservoirs (McCabe 1948) as a way to improve fishing. Implementation of these recommendations has been demanded by sportsmen.

As most screens retain only the larger fish, it must be assumed that the intent was to confine catchable-size fish. Any substantial migrations should be revealed by tag returns from waters other than those in which the fish were released. None of the ponds involved was effectively screened.

All told, only 9 out of 1,283 known recaptures (0.7 percent) were in waters other than those of original release. All were salvaged fish; no natives were ever reported anywhere but "at home." By species, 1 largemouth, 3 smallmouths, and 5 yellow perch had wanderlust.

Seven of the nine fish remained in the same township. One yellow perch moved about 8 miles downstream. Another, aided by heavy spring rains, moved through a swamp to a pond in another township. One of the smallmouths put to sea and was gaffed in Plymouth Harbor.

On the basis of these tag returns, then, it appears that constructing fish screens to retain catchable-size warm-water game and pan fish is unnecessary.

Discussion and Conclusions

The rates of game-fish harvest do not appear excessive even when the slow turnover of populations in these northern waters is considered. Pickerel, the fastest-growing and best-adapted fish, are exploited most--and can stand it. The highest harvests in any year at Cheshire Reservoir and Stockbridge Bowl did not noticeably affect either the summer fishing or the availability of fish for the next year. Bass are not particularly adapted to Massachusetts waters, owing partly to short growing seasons. Nevertheless, they are being exploited at rates well below optimum, as judged by harvests elsewhere.

Anglers recovered 21.5 percent of 2,853 smallmouths tagged in eastern Lake Ontario (Stone, Pasko, and Roecker, 1954). These were tagged on the lower jaw with rounded metal strap tags; hence the rate of return resulting from maxillary tagging (9.1 percent of 1,039 fish tagged by this method) was more than doubled. In view of a tendency evident in Massachusetts for selective capture of trout tagged on the lower jaw in this manner (unpublished), the possibility of such selectivity in harvest of the Lake Ontario fish is not ruled out.

Chance (in press) has reported known harvests ranging from about 40 to 42 percent of 1,909 maxillary-tagged largemouth and smallmouth basses in 2 small TVA reservoirs. He indicates that there is no evidence of injury to fishing in later years as a result of that exploitation.

Low utilization of pan fish contrasts sharply with exploitation of game fish in Massachusetts. If any injury to angling occurs, it would appear to be neglect of the pan fish. The latter are many times the more abundant. Failure of anglers to harvest them in substantial numbers is being compensated for by an intensive program of thinning pan fishes by use of nets, chemicals, and drainage. A need to educate anglers in the methods and opportunities of pan-fish angling is apparent.

The relative inability of anglers to harvest bass, together with their poor adaptability to Massachusetts waters, indicates how ill advised a program of promiscuous bass stocking can be. The exchange of bass for the more readily caught pickerel in many Massachusetts waters--an exchange that resulted from just such a program--has reduced the amount and quality of angling available to the license buyer.

Consequently, wherever feasible, it appears advisable to eliminate bass populations from potentially good pickerel

ponds. This will call for reclaiming many waters by drainage or by chemical treatment and restocking them with pickerel and a suitable forage species, possibly yellow perch. White perch are so difficult to harvest that they should be eliminated at every opportunity.

The harvests of salvaged fish were calculated on a basis that seems to favor a relatively high estimate of exploitation. If valid, it means that salvaged fish are more catchable than natives--and that a degree of "hook-wiseness" has developed in the native fish, which is under a more or less continuous fishing effort that is not present for the salvaged fish. This remains to be demonstrated. In any case, the costs of salvaging fish for maintenance stocking are exorbitant even on a conservative basis. Salvage operations for these purposes are indefensible--though of value in other ways.

The same amount of money would provide many times as much fishing for the angling public if invested in reclaiming unbalanced waters and in providing permanent access to "public" waters. The extreme variation in tag recoveries is probably correlated with equally variable fishing pressure. Accessibility is undoubtedly one of the chief factors that govern popularity--and the amount of recreational fishing--at individual waters.

Summary

1. For a study of angler-harvest of Massachusetts warm-water fishes, 12,978 catchable-size largemouth bass, smallmouth bass, chain pickerel, brown bullheads, white perch, and yellow perch were tagged, in 107 ponds comprising about 18,750 surface acres, during the 3-year period between September 1950 and October 1953. Of these fish, 4,829 were native to the ponds where they were caught, tagged, and released; 8,149 were salvaged from water supplies closed to fishing and released in public waters.

2. Recovery of tags was largely by voluntary mailings by anglers. Partial creel census and a reward system prevailed at two ponds. A comparison of returns under these conditions with returns from certain other waters not subject to these influences indicated that about 75 percent of recovered tags were actually reported. This was applied as an expansion factor to all known returns to estimate harvest.

3. Known recoveries among native fishes amounted to 20 percent or more of small lots of smallmouths, 60 percent of pickerel, 10 percent of bullheads, 5 percent of white perch, and 8 percent of yellow perch.

4. Liberalization of winter fishing regulations for yellow perch (1953), a result of the study, should provide increased fishing for perch. Pickerel present at any given season should be harvested then, for they probably will not contribute substantially to the fishing at a later season.

5. Estimated harvests of native fish by anglers indicate that game fish are cropped about six times as fast as pan fish. A need for research and education designed to assist anglers to harvest greatly increased quantities of pan fish is apparent.

6. Selective mortality among salvaged fish was extensive, being estimated to involve at least one-third of all largemouths, smallmouths, white perch, and yellow perch, and about one-half of all pickerel stocked in fall. About one-third of the pickerel stocked in spring may also have died shortly after release. Most bullheads probably survived after release.

7. Salvaged fish may have been more vulnerable to angling than "natives."

8. In a few ponds estimated harvests of salvaged fish were exceptionally high; namely, 28 percent largemouths, 61 percent smallmouths, 64 percent pickerel, 16 percent bullheads, and 36 percent yellow perch. White perch harvests never seemed to exceed 1 percent.

9. Though undoubtedly less costly than producing equivalent harvests of catchables in established populations by means of continuous hatchery plantings, it cost the license buyers an estimated $11 plus for each pound of salvaged fish reaching the creel--a prohibitive figure.

10. Only 0.7 percent of 1,283 known recoveries had migrated to other waters when caught. The finding invalidates earlier recommendations to screen outlets from ponds, lakes, and reservoirs to prevent loss of catchable warm-water game and pan fish.

11. If maximum angling is to be provided, management of Massachusetts waters should favor restoration of pickerel and yellow perch populations, at the expense of less readily harvested species, where proper habitat prevails. White perch populations should be eliminated wherever possible.

12. Salvage and transfer for purposes other than biologically sound introductions or restocking after reclamation (or equivalent) cannot be justified on a cost basis. Amounts of money corresponding to the "salvage budget" would provide many times as much fishing if invested in reclaiming unbalanced waters and providing permanent access to public waters.

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Writers of science fiction, desiring a new locale for their deathless prose, may find it helpful to visit waters currently under investigation.

The rays of an infra-red snooperscope are being used by research workers to watch the behavior of Pacific salmon and trout as these fish approach electronic counting devices, electric screens, and equipment designed to guide them safely past dams. The "sea scanar," a device capable of locating groups of 10 fingerlings at considerable distances, is being used to shadow salmon and trout. And a new type of electric screen separates squawfish from salmonids, stopping or killing larger predators and allowing the small food fish to pass unharmed.

EFFECTS OF SILTATION, RESULTING FROM IMPROPER LOGGING, ON THE BOTTOM FAUNA OF A SMALL TROUT STREAM IN THE SOUTHERN APPALACHIANS

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SILTATION, RESULTING FROM IMPROPER LAND-USE PRACTICES, is regarded as one of the most important factors contributing to a reduction in the acreage of desirable fishing waters in the United States. Although much information of a general nature has been published, there is a lack of quantitative data regarding the effects of siltation on stream values.

One phase of a Dingell-Johnson project, established by the North Carolina Wildlife Resources Commission during the summer of 1952, was to obtain quantitative data regarding the effect of siltation on trout streams in the southern Appalachians. The project was begun on the Coweeta Experimental Forest, located in Macon County, North Carolina, where for 20 years the U. S. Forest Service has been collecting extensive data regarding the effects of various land-use practices on experimental watersheds. The purpose of this report is to present data regarding the effects of siltation on the bottom organisms of Shope Creek, a small trout stream which receives the drainage from a 212-acre logged watershed (figure 1).

During 1942, logging was commenced on the 212-acre watershed on the Coweeta Experimental Forest. The periods of activity on the watershed were:

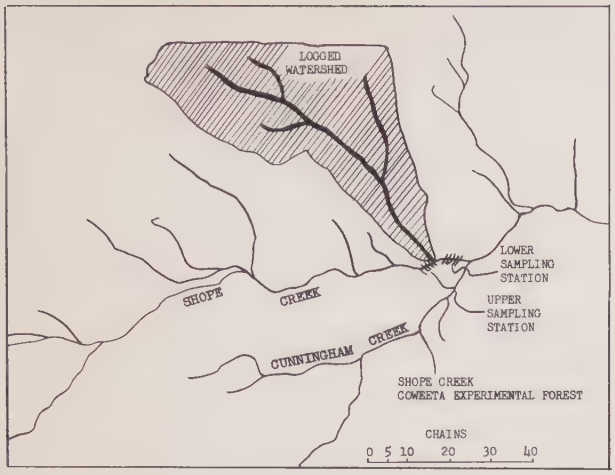
May 1942 - Mar. 1943: Active logging
Mar. 1943 - Jan. 1945: No logging
Jan. 1945 - Nov. 1948: Active logging
Nov. 1948 - Apr. 1953: No logging
Apr. 1953 - Present: Active logging

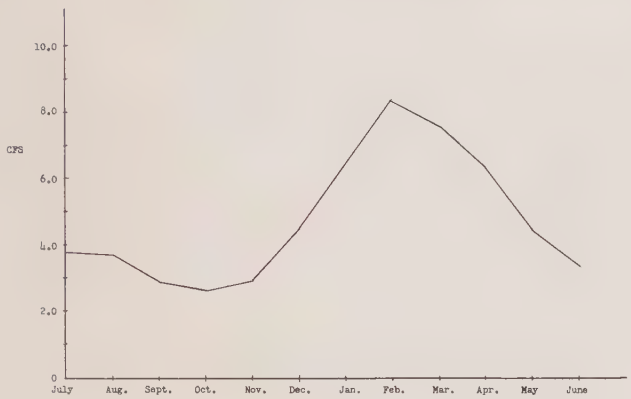
The logging was carried out by local contractors, with no limitation of methods or supervision by the Forest Service. Logs were ground-skidded by teams. Because of steep slopes, the roads and skid trails were built parallel and adjacent to the channel of the drainage stream. The roads were characterized by excessively steep grades alternating with level stretches. No surfacing material and no drains or water cutoffs were used on the roads. With the termination of the original logging in 1948, 2.2 miles of road had been constructed on the 212-acre watershed.

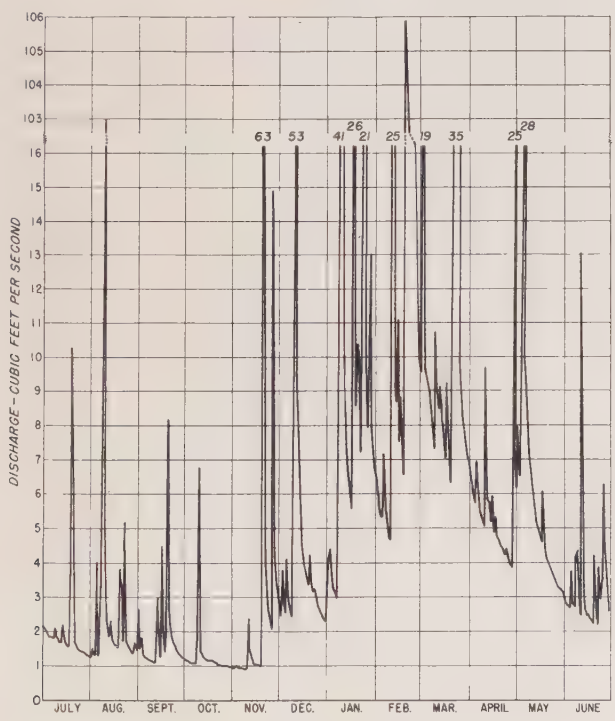
Description of Shope Creek

Shope Creek, which receives the stream from the logged watershed, flows into Coweeta Creek and thence to the Little

Presented at the Eighth Annual Conference of the Southeastern Association of Game and Fish Commissioners, New Orleans, Louisiana, November 1-3, 1954, to report on one phase of a Dingell-Johnson project undertaken by the U. S. Fish and Wildlife Service, U. S. Forest Service, and North Carolina Wildlife Resources Commission.







Tennessee River. Shope Creek drains a watershed of approximately 1,880 acres and is typical of many smaller trout streams in the southern Appalachians. Average monthly streamflow for a 6-year period ranged from a low of 2.31 c.f.s. during October to 8.32 c.f.s. during February (figure 2). Figure 3 illustrates the frequent occurrence and magnitude of floods occurring in this small trout stream.

During the period of this study, stream temperatures have ranged from a low of 33.0° F. during December 1952 to a high of 65.5° F. during August 1953. During the fall of 1953, the water had a pH of 6.6 and a methyl orange alkalinity of 8.0 p.p.m.

The upper portion of the stream is characterized by steep gradient (900 feet to the mile) with series of cascades and low waterfalls, interspersed with large pools having excellent shelter in the form of large boulders and broken water surface. The bottom is predominantly boulders and rubble with occasional outcrops of granite bedrock. From approximately one-fourth mile above the sampling stations to the lower boundary of the experimental forest, there is a noticeable change in the habitat. The gradient is 224 feet per mile, and the cascades and waterfalls of the upper section are replaced with short riffles and shallow pools. There is no rooted aquatic vegetation in the stream.

As nearly as can be determined, no trout have been stocked in Shope Creek

(Top to Bottom)

FIGURE 1.--Map of Shope Creek, Coweeta Experimental Forest, showing the location of logged area and sampling stations.

FIGURE 2.--Mean monthly streamflow (c.f.s.) of Shope Creek for the 6-year period, 1937-42.

FIGURE 3.--Peak daily streamflow (c.f.s.) of Shope Creek for the period, July 1952 to June 1953.

(Drawings courtesy of the author)

since 1930, when rainbow trout were introduced by local residents. At present, the upper and lower reaches of the stream contain brook and rainbow trout, respectively, with an intermingling of these two species in the section just above the mouth of the stream from the logged watershed. No fishing has been permitted for the past 4 or 5 years. However, prior to closure, the stream had an excellent reputation among local fishermen.

Water Quality

During storm periods, the effect of the stream from the logged watershed (Watershed No. 10) on Shope Creek is illustrated by the turbidity of water samples collected at the mouth of the stream from No. 10, from Shope Creek above the mouth of No. 10, and from Shope Creek below the mouth of No. 10.

Date	Turbidity (p.p.m.)		
	Stream from Number 10	Shope Creek Above 10	Shope Creek Below 10
Apr. 11, 1947---	1,200	25	390
Feb. 20, 1954---	1,371	67	261

The roads and skid trails proved to be the major source of turbidity (Lieberman and Hoover 1948). Skidding logs down the steep slopes creates channels which concentrate runoff, resulting in a high rate of erosion. For the 2-year period from April 1951 to March 1953, an average of 5.34 cubic feet of soil per lineal foot of road surface were eroded from the logging road. This would amount to a loss of 2,297 cubic yards of soil for the total 2.2 miles of road system.

During periods of low streamflow, the physical effects of siltation on Shope Creek are noticeably evident. During the low flows of late summer and fall, the bottom of Shope Creek above the mouth of the logged watershed accumulates a thin layer of finely divided organic matter, while below the mouth of the logged watershed the stream bottom in both pools and riffles is covered with a layer of sterile sand and micaceous material which may accumulate to a measured depth of 10 inches.

Bottom Fauna

Because of its relative stability in location, the bottom fauna was selected to obtain a measure of the effects of siltation on the stream community. The limited section of Shope Creek affected by siltation from the logged watershed made a direct evaluation of the fish population impractical. The small stream from the logged watershed is too small to support a resident trout population.

Within limits of space and reproductive capacity, the available food in a stream can certainly be regarded as a factor limiting the production of trout. Leonard (1948) and Henry (1949) have stated that in Michigan trout waters the food supply often is the most important limiting factor in trout production. Allen (1951), working on New Zealand streams, found that the bottom fauna was a limiting factor in the production of brown trout. Tarzwell (1938b) found an apparent relation between the quantities of stream foods present and trout production in streams in the southwestern United States.

In trout streams of western North Carolina the food of trout is obtained from three sources: the bottom fauna, terrestrial insects, and fish. Analysis of 241 rainbow trout stomachs collected from streams of western North Carolina during 1952 and 1953 indicate that, from January to June, 83 percent of the diet is obtained from the bottom fauna. From June to December, 42 percent of the food of rainbow trout is obtained from the bottom fauna. Terrestrial insects are of major importance during the summer and fall months. Of the 241 trout stomachs examined, only 1 specimen contained fish remains and 3 had eaten salamanders.

From October 1952 to June 1953, 108 square-foot bottom samples were collected at monthly intervals from Shope Creek immediately above and below the mouth of the stream draining the logged watershed. The standing crop of bottom organisms was at all times very low,

with a high average of 49.0 organisms per square foot occurring at the untreated station on November 13 (table 1). The highest average volume occurred in the samples of January 14 at the untreated station. The high volume occurring on January 14 resulted from an abundance of large cranefly larvae, Tipula sp., and the stonefly nymph, Pteronarcys scotti. The frequent occurrence of floods (figure 3) is undoubtedly an important factor contributing to the low quantities of bottom fauna produced in this small trout stream.

From October 1952 to February 1953, the upper station had a significantly larger numerical standing crop of bottom organisms than did the lower station, which was subjected to the siltation from the logged watershed (tables 2 and 3). The volume of bottom organisms was greater in the control section on all but two sampling dates, April 23 and May 21, 1953 (table 1).

A major flood that occurred on February 21, 1953, increased the flow in Shope Creek from 6.7 c.f.s. to 105.8 c.f.s. in a 24-hour period (figure 3). The flood completely resorted bottom materials and flushed the deposited sediments downstream, exposing the original rubble and gravel bottom. On February 26, 1953, the numbers of bottom organisms at the lower station had been reduced 73.2 percent, as compared with the January level, while the numbers at the untreated station had been reduced 22.2 percent (table 1).

High water levels plus frequent rains February to May (figure 3) prevented a reaccumulation of silt in the lower section of Shope Creek. On April 2, April 23, and May 21, that section of stream produced slightly greater standing crops of bottom organisms than did the control section. The difference was not significant ($F = 0.208$ d.f. = 1 and 30), and was the result of an increase in the numbers of mayfly nymphs in the treated section of stream (table 1). The inexplicable superiority of mayflies in the treated section of stream may have been the result of reduced competition and improvement in habitat, both caused by the February flood.

When samples were collected in June 1953, silt and sand again had begun to accumulate in the treated section of the stream, and the control section again produced a greater average standing crop of bottom organisms (table 1). The difference was not statistically significant ($t = 1.42$ d.f. = 10).

Before the reduction in the quantity of stream bottom organisms, from October through February, can be attributed to the effects of siltation, it is necessary to assume that there was no difference between the two sampled stations prior to logging. The study was commenced quite some time after logging took place, and it is therefore impossible to test this basic assumption. However, the fact that the sampled areas are on immediately adjacent and similar sections of the same stream, as well as the comparable quantities of bottom fauna produced during the spring months, when silt did not accumulate in the treated section of the stream, lends support to the assumption that there were no pretreatment differences between the two stations sampled.

With the exception of the difference in mayflies during the spring months, as noted above, there were no appreciable qualitative differences between the two stations sampled (table 1).

Discussion

The period during which the standing crop of organisms in the treated section of Shope Creek was significantly lower than in the control section coincided with the period of maximum accumulation of inorganic silt and sand. Inorganic silt and sand have poor ability to support a fauna. Tarzwell (1938a) found that mineral silt bottoms were poor in food. Murray (1938) stated that, in Indiana streams, sand by itself is likely to be barren of life.

In addition to its poor ability to support a fauna, the shifting sand created an unstable habitat, and organisms inhabiting it were particularly vulnerable to decimation by flood waters. The flood during February removed the accumulated sediments and resulted in a drastic reduction in the number and volume of bottom organisms in the treated section of stream. During

TABLE 1.--Numbers and volume of bottom organisms collected from riffles in Shope Creek from October 1952 to June 1953 at stations above and below the mouth of a tributary stream draining a logged watershed

	October 16		November 13		December 17		January 14		February 26	
	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below
Number of samples	3	3	3	3	6	6	6	6	6	6
Total number of organisms	116	74	147	78	226	137	234	164	182	44
Number per square foot	38.7	24.7	49.0	26.0	37.5	22.8	39.0	27.3	30.3	7.3
Standard deviation	9.29	13.0	12.1	14.7	13.6	6.80	15.4	16.9	22.3	3.19
Total volume (cc)[1/]	0.70	0.15	0.70	0.20	3.20	0.50	5.70	2.40	2.65	trace
Volume per square foot	0.23	0.05	0.23	0.07	0.53	0.08	0.95	0.40	0.44	trace
Diptera	27	4	57	33	65	55	90	70	76	13
Trichoptera	18	12	7	5	25	20	19	9	10	4
Plecoptera	25	9	49	-----	57	24	50	18	9	6
Ephemeroptera	30	23	22	29	53	23	54	51	36	16
Odonata	1	-----	------	-----	2	------	2	1	1	-----
Coleoptera	11	25	12	11	23	15	19	15	21	5
Oligochaeta	4	1	------	-----	------	------	------	------	------	-----

	April 2		April 23		May 21		June 12	
	Above	Below	Above	Below	Above	Below	Above	Below
Number of samples	6	6	6	6	6	6	6	6
Total number of organisms	259	283	239	249	180	196	256	202
Number per square foot	43.2	47.2	39.8	41.5	30.0	32.7	42.7	33.7
Standard deviation	17.6	17.6	19.3	26.6	9.27	15.2	11.3	10.7
Total volume (cc)[1/]	5.20	3.75	2.50	2.70	1.35	2.60	3.80	1.20
Volume per square foot	0.87	0.63	0.42	0.45	0.23	0.43	0.63	0.20
Diptera	41	33	32	24	25	16	9	10
Trichoptera	13	11	8	5	4	11	18	16
Plecoptera	41	29	24	20	17	31	75	21
Ephemeroptera	148	190	160	189	106	130	112	127
Odonata	------	1	------	------	------	------	2	------
Coleoptera	15	17	12	10	25	5	29	24
Oligochaeta	------	------	1	1	2	2	4	1
Crayfish	1	1	1	------	1	1	3	1
Salamanders	------	1	------	------	------	------	------	------

1/ Does not include salamanders and crayfish.

TABLE 2.--Analysis of variance on the basis of total numbers of organisms in October and November 1952

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Between stations--------	1	1,027	1,027	1/ 6.62
Between months----------	1	102	102	------
Interaction-------------	1	62	62	------
Error-------------------	8	1,239	155	------

1/ Significant at 5-percent level.

TABLE 3.--Analysis of variance on the basis of total numbers of organisms in December 1952 and January and February 1953

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Between stations--------	1	2,434	2,434	1/ 15.02
Between months----------	2	1,372	686	4.23
Interaction-------------	2	207	104	------
Error-------------------	29	4,706	162	------

1/ Significant at 1-percent level.

the high flows and frequent rains from February to May, the rate of dilution by clear water from the main fork of Shope Creek prevented the reaccumulation of sediment in the treated section of stream. A fauna which resulted was quantitatively comparable to that found in the control section. It is doubtful that the rapid recovery after the flood--undoubtedly by means of the drift of organisms from the control section--could occur if all of the Shope Creek watershed were subject to the effects of siltation.

The low fertility and frequent occurrence of floods in western North Carolina trout streams results in a low production of stream bottom organisms under the very best conditions. Therefore, because of the dependence of trout on stream-produced organisms, any outside factor, such as siltation, which reduces the normally low quantities of stream organisms will ultimately have a deleterious effect on the trout population.

It is apparent from the Coweeta studies that poorly planned road systems and the promiscuous use of smaller stream channels as skid trails result in a high rate of erosion and consequent siltation of the stream channel. Steep grades, lack of allowance for proper drainage, and the proximity of roads to stream channels are particularly conducive to siltation. Also, it is the opinion of many foresters that properly constructed roads, in addition to conserving water values, will, in the long run, pay the logging operator by reducing road maintenance work. Where important fishery values are involved, it is imperative that skid trails and road systems be carefully located and constructed.

Summary

1. From 1942 to 1948, a 212-acre watershed on the Coweeta Experimental Forest, Macon County, North Carolina, was logged by a local contractor. Roads and skid trails were built parallel and adjacent to the stream channel. No surfacing material and no drains were used.

2. The physical and chemical characteristics of Shope Creek, a small trout stream which receives the stream from the logged watershed, are described.

3. During storm periods the turbidity of Shope Creek was appreciably increased by the highly turbid waters from the

logged area. The accumulation of sand and silt in Shope Creek below the mouth of the stream from the logged watershed is described.

4. Roads and skid trails proved to be the major source of turbidity. From April 1951 to March 1953, an average of 5.34 cubic feet of soil per lineal foot of road surface was eroded from the logging road.

5. From October 1952 to June 1953, 108 square-foot bottom samples were collected at monthly intervals in Shope Creek at stations above and below the mouth of the stream from the logged watershed.

6. From October 1952 through January 1953, the period of maximum accumulation of sediment in the affected section of Shope Creek, there was a significantly lower standing crop of bottom organisms at the station below the mouth of the logged watershed.

7. A flood on February 21, 1953, removed the accumulation of sand and silt in Shope Creek below the mouth of the logged watershed and reduced the bottom fauna at the lower station to 7.3 organisms per square foot, as compared with 25.5 organisms per square foot at the upper station, which had not been subject to siltation from the logged watershed.

8. The February flood exposed an excellent bottom of rubble and gravel at the lower station; from February through May spring rains and high streamflow prevented the reaccumulation of sand and silt at the lower station on Shope Creek. During this period there was no significant difference in the standing crop of bottom fauna at the control and treated stations. During June, when silt had begun to reaccumulate, the control section again produced a larger standing crop of bottom organisms. The difference was not statistically significant.

Acknowledgments

Facilities of the U. S. Forest Service station at Coweeta Hydrologic Laboratory have been utilized freely in the conduct of this study. The cooperation and advice of Mr. E. A. Johnson and Dr. T. C. Nelson, technicians at Coweeta, have been particularly helpful. Mr. J. L. Kovner gave advice regarding the statistical analysis of data, and his assistance is gratefully acknowledged.

The author is particularly indebted to Mr. J. H. Cornell, Chief, and to Mr. Duane Raver, Federal Aid Coordinator, Fish Division, North Carolina Wildlife Resources Commission, who were in immediate supervision of the project and whose efforts made the work possible.

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INJECTING PITUITARY (HYPOPHYSEAL) HORMONES INTO FISH TO INDUCE SPAWNING

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IN RECENT WORKS that appeared in The Progressive Fish-Culturist, Palmer, Burrows, Robertson, and Newman (1954) and Ball and Bacon (1954) made known the results of their researches in the inducement of spawning by injecting pituitary hormones into fish. As those authors mentioned only one of the many works in this field that have appeared in Brazil to this date (Von Ihering 1937), whereas further research in this country has given very satisfactory results, we wish to offer here our contribution by describing briefly the methods used in the Serviço de Piscicultura, Departamento Nacional de Obras Contra as Sêcas, at Fortaleza, Ceará, Brazil, to induce fish to spawn. We hope that our contribution will be of some help to the above-mentioned researchers.

This method has been used only on the species that breed just once a year, at the beginning of the wet season, when they leave the dams and pools and go upstream, looking for a proper place to reproduce. Among these fish are the common curimatã, Prochilodus sp. (Characidae, Prochilodinae), piau, Leporinus sp. (Characidae, Anostominae), cangati, Trachycorystes sp. (Doradidae), and curimatã pacu, Prochilodus argenteus Spix in Spix and Agassiz (Characidae, Prochilodinae), the last mentioned being a native of the Sao Francisco River and now acclimated in the dams of Northeast Brazil.

At the fish-cultural stations, breeders of the above-mentioned species are kept in rearing ponds. In different parts of the year, the development of their gonads having been checked, the breeders are selected and transferred to aquaria, where they remain for the entire period required for the process of injecting the pituitary hormones. Transference is made a few hours prior to the first shot of the successive injections, and spawning takes place within 24 hours after the first injection.

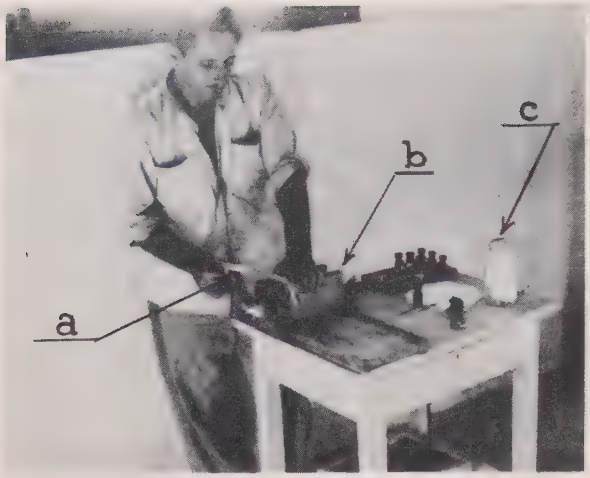
Collection and Preservation of the Pituitary Gland

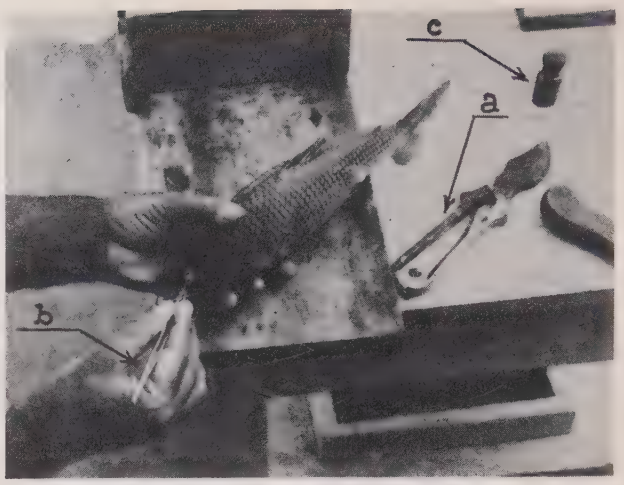
Glands are always collected from fish going to market, a few hours after death. Collection generally is made from the common curimatã, which is abundant in all of the Northeast Brazil region. However, it is necessary that the fish used show well-developed gonads, no matter whether they are male or female. This condition usually occurs in November, December, and January.

The pituitary gland of the donor fish is reached after a craniotomy. Held in a holding trough, the fish receives a transversal cut in the head, the cut being made with a common saw a little behind the ophthalmic orbits. With the help of costotome, a bony triangular lid is then lifted and the encephalon is exposed. After the encephalon has been removed with a pair of tweezers and the meninges have been torn, the gland is finally taken from its position in the sella turcica (sphenoid).

Two experienced operators can collect up to 100 pituitary glands in 1 hour.

Soon after their removal, excess fat is cleaned from the glands. Immediately





Collection of pituitary gland of a common curimatã

Transversal cut is made with common saw (a) while head is in holding trough (b). Cotton (c).

(Photographs courtesy of the author)

Bony triangular lid having been removed with costotome (a), brain is lifted with tweezers (b). Glands are stored in dark-colored 20-cc vial with ground stopper (c).

thereafter they are preserved in absolute alcohol in a sealed, dark-colored, 20-cc vial. From this they are transferred 24 hours later to an identical container in which the preserving liquid has been replaced. The glands are stored in this way, at room temperature, until they are used.

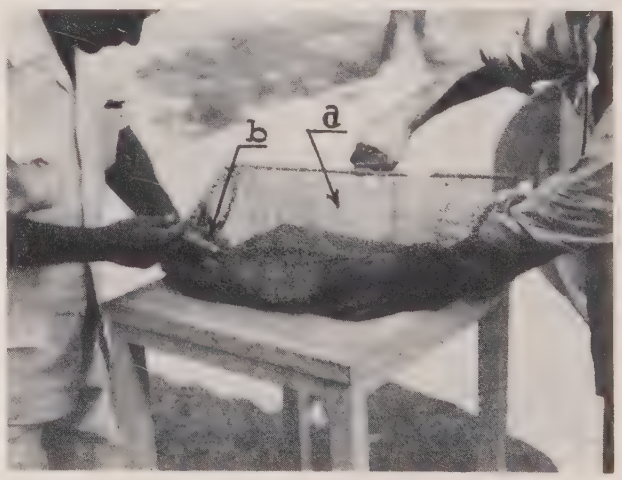
Pituitary glands thus preserved have been used over periods as long as 2 years without showing any loss of their hormone potentiality.

Inasmuch as researches conducted by biologists of the Serviço de Piscicultura, D. N. O. C. S., Brazil, have proved the nonspecificity (with regard to sex) of the gonad-stimulant hormone taken from fish pituitaries, all glands collected are kept in the same vial.

Extraction of Hormones From Pituitary Glands; Preparation of Injections

An extract of gonadotrophic hormones from the pituitary glands is made from whole glands that are taken directly from the preserving liquid (absolute alcohol), blotted lightly on filter paper, and then ground in a glass mortar with a few drops of physiological solution.

After this grinding, the resulting emulsion is diluted with physiological solution to the desired concentration. Finally it is



Making intramuscular injection of pituitary hormones of common curimatã into curimatã pacu at the tail peduncle, through the scap net (a), with a hypodermic syringe (b).

centrifuged to remove the solid part of the gland, as injections are made exclusively of hormones diluted in the physiological solution.

As until now a gonadotrophic-hormone unit has not been determined, the conventional unit injected into a fish is the amount of hormones obtained from the grinding of a whole pituitary gland taken from a common curimatã that shows well-developed gonads.

Doses are prepared a few minutes before the injection is given the fish, and they are repeated every 6 hours until spawning is obtained.

In table 1 we have transcribed figures recorded at Pôsto de Piscicultura de Lima Campos, Ceará, Brazil, as covering the treatment given lot I/1947, May 28, 1947.

TABLE 1.--Doses prepared for Lot I/1947, six male and three female curimatã pacu, May 28, 1947

Dose number	Number of pituitary glands in 4 cc of physiological solution
1	4
2	8
3	12
4	16

Technique of Making Injections

Each fish is taken with a scap from the aquarium and held on its side on a small table (0.60 by 0.60 by 0.90 meter) that stands near the aquarium and has a strong canvas substituted for its wooden top. While the assistant holds the fish's head with his right hand and has his left hand firm on the scap handle, the biologist keeps the fish's tail region on the table with his left hand and with his other hand gives the injection through the net at the convenient section.

Injections are made intramuscularly, under the scales, by means of a hypodermic syringe (of the type used for insulin injections) with a 30 by 7 needle, at the humeral regions, right and left sides, above the side line, and at right and left sides of the tail peduncle, successively.

If this technique is strictly followed, mortality will be extremely low, as the fish are not injured and no local reaction is observed except the loss of a few scales on the tissues of the muscular region where hormones are injected. We usually experiment with fish 500 millimeters long, and mortality has been very low.

In table 2 we give the schedule of the injections received by the same group of curimatã pacu, lot I/1947.

Although placed in the same aquarium, breeders of each lot are separated into two groups, at the start, according to sex. This is done with the help of a removable partition.

Exception is made of cangati, Trachycorystes sp. (Doradidae). Only the female of this ovoviviparous species is transferred to the spawning aquarium--and that

TABLE 2.--Injection of doses into Lot I/1947, six male and three female curimatã pacu

Dose:	1st	2d	3d	4th
Date:	28/5	28/5	29/5	29/5
Hour:	14	20	2	8
Suspension: (♂♂	0.10 cc = 0.10 P.	0.10 cc = 0.20 P.	0.10 cc = 0.30 P.	0.10 cc = 0.40 P.
(♀♀	0.15 cc = 0.15 P.	0.15 cc = 0.30 P.	0.15 cc = 0.45 P.	0.15 cc = 0.60 P.
Region:	S.R.	I.R.	L.S.	L.I.

Remarks: P.--pituitary gland; S.--superior; I.--inferior; R.--right side; L.--left side.

after careful examination. This examination consists of checking on whether the female cloaca is smeared with a gelatinous substance indicating that the fish has already been in contact with fish of the opposite sex.

Of course, tables 1 and 2 are only examples of the methods followed in the preparation of gonadotrophic hormones and the injection of doses, as the amount of hormones and solution varies according to the development of the breeder's gonads. Only practice acquired through repeated treatment will enable the biologist to choose the right dosage.

Spawning

Spawning usually occurs a few minutes before the injection of the fifth dose, when each male has generally received the total amount of gonadotrophic hormones contained in a pituitary gland of a common curimata, while each female has received one and a half times as much.

Spawning is preceded by a state of accentuated agitation on the part of reproducers. At this time the partition is removed and the reproducers of both sexes are allowed to meet.

We rarely use artificial fecundation, always allowing sufficient time for the spawning to take place naturally in the aquarium.

Once spawning has been completed, reproducers are put away in the ponds and the eggs are collected for artificial incubation.

Examination of breeders submitted to injections of pituitary hormones shows--a little prior to spawning--maturation of gonads. The male issues fluid sperm upon slight pressure of the ventral region, and the female indicates hyperemia of the genital papilla as well as an accentuated flaccidity of the ventral region.

Current Research on Spawning Induced by Injections of Pituitary Hormones in Fish, Serviço de Piscicultura, D. N. O. C. S.

We are making extensive experiments with a view to improving the technique of using injections of pituitary hormones to induce fish to spawn. These experiments are aimed at the following:

1. Use of liquid other than physiological solution, permitting slower absorption and thus reducing number of injections.

2. Use of injections obtained exclusively from the front lobe of the pituitary gland, the objective being to investigate the existence of hormones that may retard the maturation of the gonads.

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A DIRECT-CURRENT FISH-SHOCKING TECHNIQUE

Jack E. Bailey and John C. Spindler, fishery biologists assigned to a "test stream" study conducted in Flint Creek near Philipsburg, Montana, by the Montana Fish and Game Department, have reported the development of a direct-current fish-shocking technique using two negative electrodes and one floating positive electrode.

Messrs. Bailey and Spindler describe their technique as follows:

"Fish are 'repelled' from the two negative electrodes near the stream banks and 'attracted' to the floating positive electrode near the center of the stream channel. This system is particularly advantageous in Flint Creek where dense willows along the banks would make netting of shocked fish extremely difficult if it were not possible to 'attract' the fish into the open channel. Fish attracted to the positive electrode in water ranging from 1.4 to 3.5 feet per second line up at the surface of the water along the downstream edge of the triangular wooden electrode frame and are easily captured in a dip net. In water of lower velocities, it is necessary to move the positive electrode in such a way that 'attracted' fish will swim along at the trailing edge until netted. In water of higher velocity than 3.5 feet per second, the shocked fish are simply swept downstream by the water current and are captured later in a more favorable spot.

"The floating wooden triangle of the positive electrode is attached to its handle by a strap hinge which gives the desired flexibility as well as sufficient control over movement in the horizontal direction. Thin-wall conduit (either 0.75 inch or 1 inch in size) provides light yet sturdy handles and frames for dip nets and electrodes. Common copper screen (16 mesh per inch) is used for the electrode surface of the positive electrode, and copper tubing (0.125 inch) is used for the grids on the negative electrodes."

A NEW METHOD OF TREATING SALMON EGGS AND FRY WITH MALACHITE GREEN

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Clyde D. Adams, U. S. Fish and Wildlife Service, Underwood, Washington
Robert J. McElrath, U. S. Fish and Wildlife Service, Underwood, Washington

IN RECENT YEARS use of malachite green treatments to inhibit the growth of fungus on incubating eggs and fry has been widely adopted in salmon hatcheries. Where any large number of eggs is involved, there is a definite saving of labor, and often a reduction in mortality, when the chemical is used throughout the incubation period. Prior to the development of this method of fungus control, the fish culturist had two choices during the incubation of green eggs: he could leave the eggs undisturbed in baskets or trays until they were eyed, a course which allowed the ever-present fungus to spread and kill many good eggs; or he could pick the eggs during the tender stage and thus reduce losses from fungus at the cost of killing some eggs by handling. Semiweekly treatments with malachite green at a concentration of 1:200,000 for 1 hour eliminate both the losses from fungus and the necessity for handling during the tender stage.

The commonly used methods of controlling fungus with malachite green are similar to those described by Burrows (1949), in which a concentrated solution of malachite green is introduced into the troughs by means of a constant siphon. Although this method of fungus control is effective, some difficulties are encountered when it is used on a large scale in a production hatchery. These difficulties include the following: (1) The siphons are difficult to keep in adjustment, the fine nozzles often becoming obstructed with dye crystals or debris; (2) in hatcheries where many troughs are to be treated, many of the siphon jugs must be used and require constant attention during treatment; (3) the glass jugs and tubing used are easily broken; (4) filling the jugs is a slow, disagreeable task offering many opportunities for spilling the dye and staining flesh, clothing, and equipment.

A number of devices have been suggested to reduce the labor involved and overcome some of the difficulties encountered with the original method. In planning an installation for use at the U. S. Fish-Cultural Station at Spring Creek, Washington, it was decided to use a pump driven by an electric motor to inject a measured quantity of concentrated malachite green solution into the main water supply line before it entered the hatchery and thus to treat all the water then in use. (See diagram of the device.)

The pump draws the malachite green solution from the storage tank and forces the solution either into the by-pass line or through a meter. The meter consists of a tapered glass tube etched with graduations of 10 to 100 percent. The solution passing through the meter raises a metal "float" within the glass tube, and the location of this float in relation to the graduations indicates the flow in percentage of total capacity. The rated maximum capacity of the meter is 2.70 gallons per minute, which is the amount of liquid passing through the tube when the float is at the 100-percent mark. The position of the float is regulated by adjustment of the by-pass needle valve, which, when open, allows part of the solution to return to the

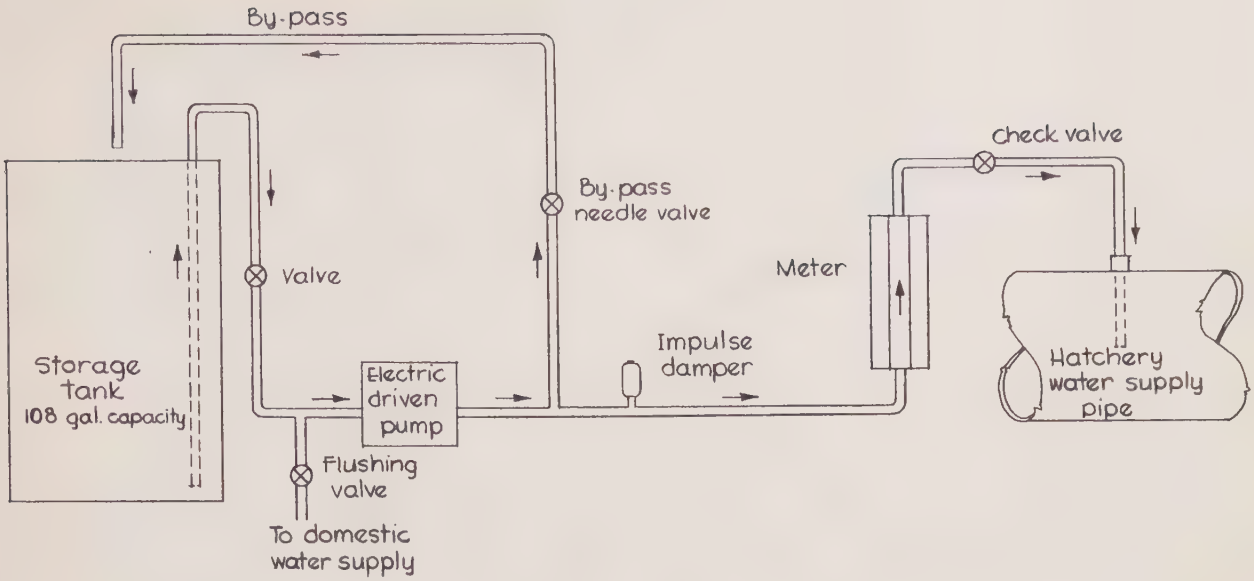

Diagram of typical installation of apparatus for treating hatchery water supply with malachite green.

storage tank without flowing through the meter. The impulse damper, a small metal tank, is designed to reduce fluctuations in pressure of the malachite green solution before it enters the meter.

The malachite green solution on the discharge side of the meter passes through a check valve and is injected into the hatchery water supply pipe just past the main control valve. Here a 3-inch pipe coupling has been welded into the top of the metal pipe and the 0.5-inch pipe from the meter passes through a pipe plug in the coupling and is extended to the center of the large water pipe. To achieve a more rapid and thorough mixing of the solution and the water, a small metal baffle plate has been welded to the side of the discharge pipe, extending 2 inches past the open end.

At Spring Creek, the apparatus was installed in the valve box just outside the hatchery building. The main water line passes under the hatchery floor for about 40 feet before reaching the standpipe for the first troughs, and part of the excellent mixing obtained probably was due to the distance the water flowed in the pipe after the malachite green was introduced.

In a subsequent installation at another hatchery, the malachite green solution was injected into the water supply pipe about 4 feet from the standpipe for the first troughs. Adequate mixing was also obtained here.

Where 108 troughs were to be treated, the procedure was as follows:

1. Two pounds of malachite green crystals were dissolved in a pail of warm water and poured into the storage tank, which was then filled with water to the 100-gallon mark. This made a solution of about 1:417.

2. Water flow into each trough was adjusted to 7.5 gallons per minute.

3. Motor and pump were started. By adjustment of the by-pass needle valve, the float in the meter was raised to the 62-percent mark, which indicated a flow of approximately 1.67 gallons per minute through the meter. This made a solution of about 1:203,000 malachite green in the water line and in the troughs.

4. The pump was operated for 60 minutes, during which time 100 gallons of solution were injected into the water line.

5. Pump and meter were flushed with clear water.

Semiweekly treatments were administered to all fall chinook salmon on hand during the egg and fry stages until the fish were ready to start feeding. Adjustments were made in the amount of malachite green crystals in the stock solution when some of the troughs were not in use after eyed eggs had been shipped to other hatcheries, and when the water flow per trough was increased to 10 gallons per minute during the late fry stages.

Results obtained from treatments with this apparatus at the Spring Creek Station during 1953 were satisfactory. There was little evidence of fungus on eggs or fry, and there was no abnormal mortality that could be attributed to the method of treatment. Visual observations indicated that there was a uniform distribution of the malachite green throughout the hatchery troughs. The device injected 100 gallons of concentrated solution into the pipe line with a variation of plus or minus 1 minute from the desired time of 60 minutes, and it is believed that the concentration in the troughs was more precise and uniform than when conventional siphon bottles were used.

There was also a significant saving in the labor required for treatments. With siphon bottles, about 8 man hours were required to complete the treatment for 108 troughs; whereas by the new method the same treatment could be accomplished in 1.5 hours. The cost of the installation was approximately $300 and will soon be repaid in labor savings.

Acknowledgment

Credit is due Messrs. Stanley G. Conn, superintendent of the Willard (Washington) Station, and Emil S. Pearson, in the Portland (Oregon) office of the U. S. Fish and Wildlife Service, for their earlier work in devising a method of introducing malachite green into a hatchery water system. The method that was devised by Messrs. Conn and Pearson involved use of compressed air instead of an electric pump.

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SPECIES STUDIED IN FEDERAL-AID PROJECTS

Among the most interesting investigations conducted during the past year as part of the Federal Aid in Fish Restoration Program were a number of projects dealing with particular species. These projects were undertaken because certain species were of such importance as to require a thorough understanding of the life cycle or the place in the State fishery program.

As an essential part of effective fish management, the State of New Hampshire continued an investigation of the bass to determine the success of natural reproduction, present populations, effect of fishing pressure, and food habits. New York studied the weakfish and the striped bass in order to expand those fisheries and studied the carp for means of controlling it. Wisconsin's largemouth bass work was designed to permit manipulation of populations on a number of lakes. Hawaii investigated the life histories of gobies. California projects included life-history work on the catfish, the yellowtail, and the steelhead.

SILVER SALMON *(ONCORHYNCHUS KISUTCH)* REPRODUCTION IN MONTANA

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State Fish Hatchery
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SILVER SALMON (Oncorhynchus kisutch) from sea-run stocks have been liberated in certain Montana lakes over the past many years. Plantings have been made most regularly into Georgetown Lake, Granite and Deerlodge Counties, and Crystal Lake, Lincoln County. The annual supply of eggs from sea-run silver salmon has never been completely reliable. Montana, being the last recipient on the list, would not receive eggs during years when there was a shortage of spawn taken. As this species of fish fills a management niche in certain waters in the State and provides so much recreational fishing for the Montana angler in these waters, concern has arisen over the future supplies of eggs.

There has been no indication that silver salmon planted in Montana lakes have reproduced, even though at least two lakes have inlets used extensively by trout for spawning. The observations reported in this paper were made as the first step in determining feasibility of (1) establishing a source of land-locked silver salmon eggs, and (2) establishing a population of land-locked silver salmon that would reproduce naturally. The observations made were designed to answer two questions: (1) Is it possible to rear fish from eggs stripped from and impregnated by silver salmon of sea-run parentage that have spent their entire life cycle in fresh water? and (2) can fish thus produced, after being held as brood stock in a hatchery for their entire life cycle, be spawned successfully?

Material and Methods

During the week of January 18-24, 1948, 77,300 eyed silver salmon eggs were shipped to Montana hatcheries. These eggs had been taken from sea-run fish on December 6, 1947, at the Soos Creek traps, Green River Fisheries Station, Auburn, Washington. Fish from these eggs were reared in Montana hatcheries to a size of 3 or 4 inches in length and were planted in Georgetown and Crystal Lakes in July 1948.

Georgetown Lake is an impoundment which supplies a small amount of water for power generation and supplies water by pumping to the city of Anaconda for municipal use and to the Anaconda Copper Mining Company for smelting operations. The lake is at an elevation of 6,000 feet and is ice-covered from November until sometime in May. It has an average depth of 18 feet, a normal fluctuation of 4 feet during a year, and a surface area of 3,000 acres. There are two inlets, Stewart Mill Creek and Flint Creek. Stewart Mill Creek arises as a spring about 100 yards from the lake; Flint Creek is a longer stream, fed by runoff and seepage. The latter stream is completely dry at its mouth during the winter. The Fish and Game Department takes trout eggs from weirs on both streams.

Crystal Lake is a much deeper lake, located in the northwestern part of the State. It is at an elevation of 3,100 feet, has a surface area of 216 acres, and has neither inlet nor outlet.

Eggs taken in the course of this experiment were hatched and the fish reared at the State Fish Hatchery, Anaconda, Montana. The daily water temperature at this hatchery ranged from 44° to 48° F. at the time the silver salmon eggs were in the hatchery.

The fish planted in Georgetown Lake in July 1948 matured during the winter of 1951. On January 14, 1951, two ripe female and two ripe male silver salmon were obtained from fishermen. In 1952 and 1953, eggs were obtained from additional stocks of fish liberated in Georgetown and Crystal Lakes. Gill nets were used to take fish from Crystal Lake, but public opinion made it necessary to obtain fish from Georgetown Lake by angling.

Findings

On January 14, 1951, 2 ripe female and 2 ripe male silver salmon were obtained from fishermen on Georgetown Lake. The eggs that were obtained averaged 153 to the ounce. Losses during the incubation period were large, but embryos developed in 30 days in the eggs that survived. Additional eggs were obtained from both Georgetown and Crystal Lakes in January 1952 and January 1953.

On January 4, 1954, from these 3 egg takes, there were in the hatchery 274 3-year fish, 1,000 2-year fish, and 200 yearlings. Of the 3-year fish, 49 percent (47 females and 91 males) were mature. The mature females averaged 1.1 pounds in weight and 13.4 inches in total length, while the mature males averaged 0.95 pound and 13.3 inches. The immature fish averaged 0.42 pound and ranged in length from 7 to 10 inches. The ovaries of 3 immature females examined ranged in length from 4 to 4.5 cm.

On January 11, 1954, 18 males and 18 females were spawned. Fish were spawned three more times as they became ripe. The results of these operations are shown in the table. Eggs from those fish spawned on January 11 were taken by the stripping method, whereas eggs obtained at succeeding times were taken by opening the abdominal cavity. A total of 20,974 eggs were obtained from the brood stock.

Eggs from 3 of the females stripped on January 11 were kept separate, and the body cavities of these fish were opened. In this way, 625 additional eggs were obtained, making a total of 2,101 eggs from 3 females or an average of 700 eggs each.

Of the eggs spawned on January 11, 74.5 percent were lost by the eyed stage. Eyeing required 25 days. Of those eggs taken on January 18, 73.9 percent were lost by the eyed stage. There was a loss of 100 percent in 1 lot of eggs that had been fertilized with sperm from an albino male.

Conclusions

It has been demonstrated that eggs taken from mature land-locked silver salmon whose parents were of sea-run stocks can be fertilized and hatched, and the resulting fish can be reared in hatcheries. Further, it has been demonstrated that such fish, when held in hatchery brood ponds until maturity, can be spawned and the fertilized eggs will develop and hatch.

Results of spawn-taking operations from silver salmon brood stock, State Fish Hatchery, Anaconda, Montana

Date spawn taken (1954)	Number of females	Ounces of eggs	Number of eggs per ounce	Number of eggs per female	Number of eggs
January 11	18	69	119	457	8,241
January 18	12	69	119	684	8,211
January 25	3	18	119	714	2,142
February 1	4	20	119	595	2,380

Loss of eggs to the eyed stage was large, but thereafter losses in fry and fingerling fishes were normal as compared to the losses of other fishes reared in the same hatchery.

As fish may be reared artificially from land-locked silver salmon parents, it would be desirable to determine why these same land-locked fishes have not reproduced naturally in Montana lakes.

POWER-LIFT EQUIPMENT IN THE GRINDING ROOM

From the Oregon Game Commission's Oak Springs Hatchery, where more than a half million pounds of fish food are ground during a year, Superintendent A. B. Smith reports that use of a power-lift ground-food hopper saves the labor of one man and reduces waste of food.

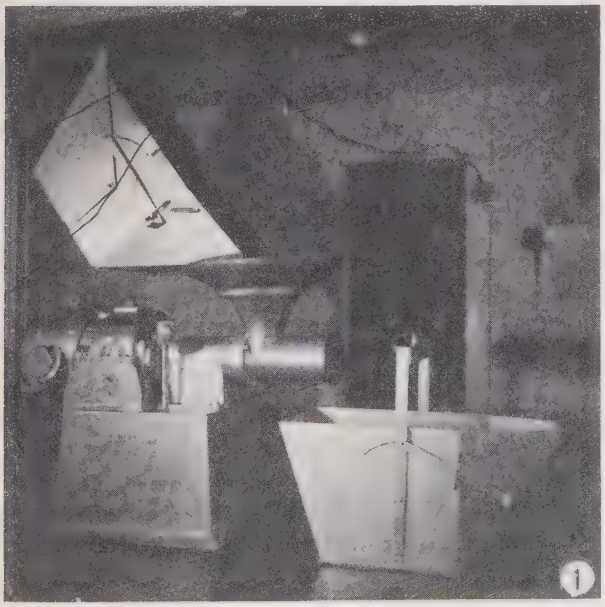
The food grinder (see figures) at the hatchery is driven by a 25-horsepower 3-phase electric motor and has a first-grind capacity, through a 3/8-inch plate, of about 1 ton per 15-minute period. As used earlier, the machine filled about 3 buckets (capacity, 40 pounds) a minute, requiring one man to handle buckets and another to feed and tend the machine.

The food vats pictured have a ground-food capacity of 700 pounds. The overhead hoist and trolley system has, for speed and safety purposes, a capacity of 1 ton.

Figure 1 shows the present grinding cycle. An empty vat is put on the floor to receive the output of the grinder, and unground food is fed into the hopper. When the vat is full, it is raised by hoist to the bar and thence to a position above the mill for regrind. Formerly some 18 buckets had to be handled (and cleaned after each grind); now all lifting is by machine, and but a single vat is cleaned between grinds.

Figure 2 shows in greater detail the lifting of the vat and the trolley track used for horizontal travel.

Mr. Smith notes that the hoist (developed with the assistance of Mr. Ed Suiste, second hatcheryman at Oak Springs, and the cooperation of the Commission's engineering staff) has yielded an annual work-cost saving of about $900 for an initial capital investment estimated to be $750.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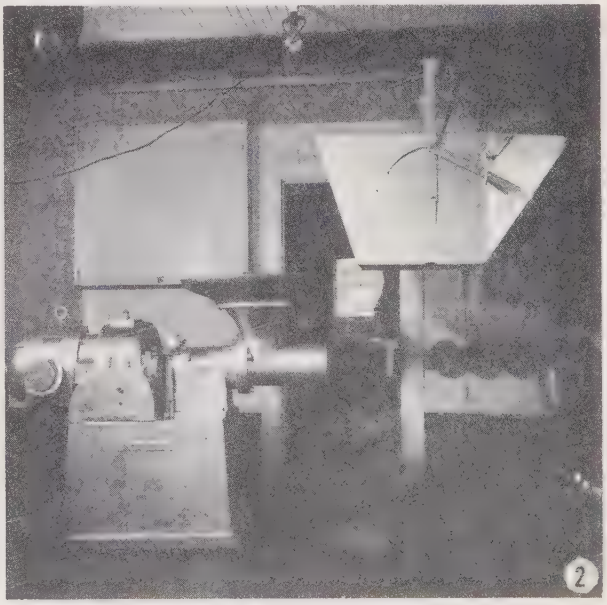
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MULTI-PURPOSE ELEVATED HOLDING TANKS FOR YEARLING TROUT LIBERATIONS

K. E. Morton
Wizard Falls Hatchery
Camp Sherman, Oregon

AT FISH HATCHERIES where large numbers of yearling fish are reared annually, the new facilities designed and built by the writer, and herein described, may be of help and interest.

The accompanying photographs show the construction and operation of elevated holding tanks that have worked out very well at the Wizard Falls Hatchery of the Oregon State Game Commission. The tanks were built primarily to eliminate excessive overtime and because it was felt that the procedure would have a beneficial effect in conditioning the fish prior to long hauls. The convenience of being able to load the tanks at the most opportune time of day has helped considerably in smoothing out hatchery operations. At the height of the busy season it is often necessary to haul loads on weekends, and formerly much overtime was accumulated in keeping a loading crew available. With the holding tanks in operation, the loads are ready for the trucks whenever they call--whether it be at 5 o'clock in the morning or on a weekend--and employees enjoy more days off on schedule. The truck drivers appreciate the time saved in loading, as they can arrive at their destination 1 hour ahead of old schedules when the fish were loaded directly from the ponds.

The idea of loading fish from an elevated tank was conceived while watching a gravel truck back under a loading bunker. Further thought on the matter brought to mind the tipping waterspouts on the elevated water towers seen along railroads. Now that we have the tanks in operation, we don't know how we ever got along without them.

The Wizard Falls Station is situated on the headwaters of the Metolius River at a 3,000-foot elevation in central Oregon, and cold weather occurs well into June. Loading 600 pounds of fish in the early morning hours under freezing conditions was a task not overly enjoyed by the crew. Now the tanks are usually loaded in the afternoons, after the morning rush hours are over, when it is warmer, and a much better job is done in handling the fish.

Figure 1 shows the new facilities. At lower left, on an excavated ramp, a large tanker is ready for loading. At upper right, on a raised ramp, is a pickup truck holding a transfer tank, in which the fish have been moved from the pond and from which they will be poured into the loading trough for counting and release into any one of the three elevated holding tanks. A sloping, shaded area is best suited for constructing such facilities.

The transfer unit, placed on the pickup, is being loaded in figure 2. As the fish are in this portable tank only a few minutes, 200 pounds of fish are carried without aeration. The pipe roller under the unit facilitates its removal to a prepared platform when not in use.

In figure 3, the wood plug (held in place by metal clamp) has been removed and the fish are passing over the short trough that fits snugly into grooves cut in the side of the transfer unit. In the black loading and counting trough, fish can be counted over small crowders and then -- through small

(Left)
FIGURE 1.--The new handling setup.

(All photographs by Mr. Hugh Black)

(Above)
FIGURE 2.--From the pond to the transfer unit.
FIGURE 3.--From the transfer unit to counting trough.

(Right)
FIGURE 4.--From one of three holding tanks to distribution unit.

trap doors--can be released into any one of the three tanks. Screens keep the fish from jumping out. The separate water supply for the counting trough can be seen.

Loading of the liberation tanker is shown in figure 4. First step is to run 12 inches of water from the filling hose into the tank to act as a cushion for fish. Then the elevated tank is drained--through separate drains--to a predetermined level so that the truck will not overflow. The 6-inch metal flex tubing is unhooked and lowered to the tank truck hatch. When the wood gate that slides--in grooves inside the elevated tank--over the tube opening is raised, the fish and water run into the tank truck.

Seven hundred and eighty pounds of fish have been loaded in 5 minutes, permitting the driver to reach his release point an hour earlier than would have been possible with the old loading method.

The elevated tanks have a constant flow of fresh water running through them. By holding each load for 48 to 72 hours before hauling, it is possible to have practically all of the excreta carried off through the separate cleaning drains, thus eliminating the clogging of screens of the circulation system of the tanker.

As the counting trough is built into the tanks and supplied with fresh water, much larger poundages of fish are counted with less distress to the fish and with increased accuracy.

Numerous tests were made, under controlled conditions, by Mr. Ross Newcomb, in charge of fishery research for the Oregon State Game Commission, to determine what effect the new loading procedure would have on factors associated with postliberation mortality.

Anyone who desires to duplicate such an installation should be reminded that the dimensions required at different stations will depend on water pressure, the type of planting truck used, and the available terrain on which to build. The writer would suggest that the size of the tanks be increased from 10 feet in length to at least 16 or 20 feet in length at stations where large numbers of fish per load are hauled. In one of these tanks, 780 pounds of fish were held for 48 hours with no ill effects, but it is felt that more space would permit better conditioning. It is planned to change the water supply to the tanks from the hatchery spring (water temperature, 50° F.) to the colder Metolius River. The spring water has only 7 to 8 p.p.m. of oxygen, whereas the river water (4° to 6° colder) contains oxygen at the saturation point.

POPULATIONS IN POLLUTED AND UNPOLLUTED WATERS

In the Monongahela National Forest, between September 1953 and October 1954, differences in fish populations were recorded for four streams affected by strip-mining and three unpolluted streams.

In unpolluted streams, brook, brown, and rainbow trout made up only 1.0 percent by numbers but 27.8 percent of the total weight of fish taken. No trout were taken in the polluted streams.

Suckers comprised 10.6 percent of the number and 40.7 percent of the total weight taken in polluted streams. In the unpolluted waters, however, suckers made up only 2.2 percent of the number and only 3.3 percent of the total weight.

Though the number of minnows taken in polluted and unpolluted streams was very close (76.6 and 75.2 percent), these fish made up 62.7 percent of the total weight taken in unpolluted waters and only 40.6 percent in polluted streams.

Forming 20.6 percent of the number of fish taken in unpolluted streams and only 9.3 percent in polluted streams, darters nevertheless made up only 1.4 percent of the total weight taken in polluted streams and 5.6 percent in the unpolluted waters.

OBSERVATIONS ON THE FIELD USE OF CRESOL AS A STREAM-SURVEY METHOD

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COMMERCIAL CRESOL has been used extensively as a survey method for sampling the trout populations in Tennessee streams. It has been very effective for determining the limits of trout water, the presence of reproduction, and the approximate carrying capacity of a stream. At present, cresol is being used to supplement original survey data and to follow the progress of experimental trout releases. It is equally useful for sampling fish populations in small warm-water streams.

The electric shocker has proved ineffectual in our mountain streams because of the extremely low conductivity of the water. Carbonate hardness in the majority of eastern Tennessee trout waters ranges from 4 to 30 parts per million. The threshold level of conductivity that is required for efficient use of a standard 210-volt A.C.-D.C. shocker is approximately 45 parts per million. The portability of cresol and the small amount of equipment needed make it very practical for use in remote headwater streams.

Embody (1940, 1941) described the advantages of cresol as a sampling agent and the procedure for calculating proper rate of application. He also conducted laboratory experiments to determine the toxicity of cresol in relation to the size of the fish, the concentration of the chemical, and the temperature of the water.

The concentration of cresol is rated as to its phenol equivalent as a disinfectant. The highly concentrated phenolic emulsifiable disinfectant (coefficient 30) offers the advantages of efficient recovery and small amount of agent required. Lesser concentrations have been used but with a notable decrease in success.

The effect of cresol is apparently one of respiratory membrane irritation and depletion of dissolved oxygen. The chemical is usually introduced at a narrow and turbulent point in the stream where natural mixing action quickly carries it into emulsion. The fish normally surface within 2 minutes; they are captured with dip nets as they drift helplessly or thrash about, seeking relief from the effect of the chemical. Complete recovery in fresh water is usually effected in 3 to 5 minutes. Fish that are overlooked revive as fresh water displaces the treated water in the test area. The stream section sampled may then be measured, and the results obtained may be applied to an estimate of standing crop in terms of number and weight per acre or mile of stream.

The most economical rate of application must be determined by experience, as stream volume, velocity, turbulence, carbonate hardness, pool area, and temperature all affect the length of stream sampled. However, the general rule of 1 gallon cresol (p.e. 30) per 4 cubic feet a second for 100 yards of stream is useful. Any length of stream may be treated by adding enough chemical at downstream intervals to maintain an effective concentration. The use of cresol is not practical in streams having volume of flow greater than 25 cubic feet per second.

Experimental releases of fin-clipped hatchery trout, 1 hour before introduction

of the cresol, have resulted in recovery rates ranging from 72 percent to 95 percent. Turbidity, volume of flow, and amount of escape cover are the primary factors affecting recovery. The stream area may be treated a second time if a more complete estimate of the population density is desired.

Cresol can be used successfully at all temperatures, but loss of strength through volatilization is more rapid at higher temperatures.

Brown trout are slightly more resistant to the effects of cresol than are the rainbow and brook trout. No appreciable difference in susceptibility of wild and hatchery trout was noted.

Approximately 150 wild rainbow and brook trout, collected with cresol and transferred to hatchery ponds, showed no deleterious effects from exposure to the chemical.

Aquatic insects, especially the caddis and mayfly groups, drift helplessly upon contact with cresol until they are carried into quiet water. A period of 20 to 30 minutes is required for their recovery from the cresol.

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TILAPIA

In recent months a number of popular magazines in this country have published articles dealing with Tilapia, describing the success with which Tilapia mossambica has been propagated as a food fish in various Asiatic countries. The considerable public interest aroused by these articles has been reflected in the offices of the U. S. Fish and Wildlife Service by the number of inquiries received from people who wanted information about the possibility of raising Tilapia in the United States.

Because of the widespread interest in propagating in this country the highly praised Tilapia, it seems advisable to call attention to several points that merit careful consideration before culture of the fish is undertaken.

Originally a native of tropical Africa, Tilapia is quite unable to withstand the climatic conditions that prevail in most of the United States. The fish will not survive temperatures below the range of 50° to 55° F.

With regard to growth or production under our conditions, Tilapia apparently can offer little advantage over domestic species. Tilapia has a high reproductive potential--as have many fishes--and would develop stunted overpopulations in such ponds as provided suitable habitat. Fish of very small size--although they may be acceptable to the protein-hungry peoples living in various crowded Asiatic countries--are not regarded as edible in the United States.

Tilapia may be purchased from dealers in aquarium fishes in the United States. Private individuals are cautioned, however, against stocking or propagating Tilapia without first obtaining the approval or permission of their State conservation department.

At least until careful experimental work has demonstrated the usefulness of Tilapia as a food or sport species in this country, the Fish and Wildlife Service cannot encourage its introduction into our natural waters.

UTILIZATION OF HATCHERY FISH

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Washington State Game Department
Seattle, Washington

FOR A NUMBER OF YEARS the Washington State Game Department has been pushing vigorously a program of lake rehabilitation. Briefly, the program consists of treating lakes chemically to eradicate existing undesirable fish populations and replanting with desirable game fish. In all, 209 lakes have been treated so far. These have ranged in size from small ponds of 5 acres or less to lakes of nearly 900 acres.

The primary purpose of the program is to provide the best fishing possible. Economically it has proved particularly successful.

In untreated lakes having mixed populations of both game fish and nongame fish, it was found that fair fishing could be provided by planting trout that were legal sized (6 inches) or larger. However, these plants were very costly and caused considerable controversy among fish men as to whether they could be justified. Without allowing for capital-investment charges, interest, or depreciation, it costs about 79 cents across the board for every pound of trout produced by Washington game-fish hatcheries.

If we allow for a return of 50 percent to the angler from planted legal-sized fish, we can readily see that it is an expensive proposition to put a dozen trout in a fisherman's creel. In case there is a question, we will say that we are being very generous with ourselves by suggesting a return of 50 percent from the type of water we are talking about.

Treated lakes, for the most part, have been restocked with advanced fry or small fingerlings. Naturally these smaller fish are far less expensive than an equal number of larger ones. Large numbers can be planted in a body of water for the same amount of money represented by the production of a relatively few large fish.

At the start of the rehabilitation program, the plantings were based on the more obvious factors known to govern the success or failure of plants. Some of these factors are temperature conditions, season of the year, abundance of food organisms, and size of available fish at hatcheries.

After we had treated and restocked a substantial number of lakes, we had an opportunity to observe and compare results. It was apparent that yields of trout varied considerably between lakes. These variances ranged from near total failures in some instances to the other extremes where production was so high as almost to give the impression that every planted fish had survived and was subsequently caught.

In order to increase our efficiency and improve conditions at "poor" or "fair" lakes, a careful analysis was made of all circumstances from the time the fish left the hatchery until their ultimate harvest.

First, it was observed that we were consistently having better success with eastern Washington lakes than with western Washington lakes. Next, it was noted that plantings made in eastern Washington lakes consisted of fish averaging a larger size than those going in western Washington lakes. Statewide, plantings were made at a comparable time--usually between March and mid-June in the waters at lower elevation.

Plantings made in rehabilitated lakes in eastern Washington usually were composed of fish running from 200 to 500 per pound, while plants in lakes in western Washington usually were composed of fish running from 1,000 to 1,400 per pound.

The difference in size was caused primarily by lower water temperatures in western Washington hatcheries. To counteract these lower water temperatures and to insure larger fish for early stocking, eggs from fall-spawning rainbow trout are now procured for the cold-water hatcheries. Hatchery superintendents were also informed of the need for larger fish and--by using improved cultural techniques--provided them.

Recent plantings of fingerling trout, 500 per pound or larger, into a number of trout lakes in western Washington have greatly increased annual catches. Several lakes which had been failures under the old stocking methods are now listed among the "hot" fishing waters.

In considering the reasons for the low survival of small trout fingerlings in the 1,000 to 1,400 per pound group, several observations have been made. First, trout of this size feed almost exclusively on zooplankton, which often exhibit tremendous fluctuations in abundance. Small trout planted during a period of low abundance would have less chance to adjust themselves to the change from artificial feeding to foraging on natural foods. Frequently the magnitude of the hatchery program was such that space did not allow the holding of small trout until favorable plankton "blooms" were observed. Second, larger forms of aquatic life, such as insect larvae, are frequently found when plankton forms may not be numerous. Trout capable of feeding on foods larger than plankton thus could survive in greater numbers.

Factors other than food also play an important role in higher survival of the larger fingerlings. They not only are capable of utilizing a wider variety of foods but also are generally much stronger physically, are able to escape predators better, and thus more readily survive the transition from hatchery to natural habitat.

The larger fish (200 to 500 per pound) also provide a more desirable trout a year after planting, when they first become available to the angler. These fingerlings make the transition to natural foods more easily and continue growth, whereas the smaller fingerlings may lose 1 to 2 months of the summer growing season before they become completely adapted to natural conditions. In some waters which may not be so productive as others, the use of the larger fingerling is essential if suitable and catchable fish are to be provided for the following fishing season.

The foregoing discussion concerns only one size of trout provided by the hatcheries. The successful utilization of legal-sized trout from hatcheries demands similar attention. Field biologists are continually following groups of released fish to ascertain survivals and to determine the many factors involved in successful management of the waters under their supervision. The success of both the hatchery program and the fishery-management program is almost entirely dependent on how closely the hatcheryman and the biologist cooperate.

To be successful, the hatchery program must be planned to provide the biologists with healthy fish of the sizes needed and when needed.

The necessity to keep the glass of aquaria unclouded with moisture during visiting hours is no longer a problem at the U. S. Fish-Cultural Station at Guttenberg, Iowa. The superintendent, E. C. Saeugling, reports that glass cleaned in the morning with a sponge saturated with ammonia remains free of condensation and permits 100 percent visibility of the fish throughout the day.

A STREAMLINED STUDY OF NEW YORK SALMON

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UNDER THE HEADING "Salmon (Salmo salar)" the following paragraph appeared in the Report of the Commissioners of Fisheries of the State of New York for 1871:

> In order to test the question whether there were any waters in this State adapted to salmon culture, and in order to supply them, if any were found, the Commissioners of Fisheries exchanged 2,000 salmon-trout fry and 2,000 young white-fish with Mr. Wilmot, of Newcastle, Canada, for 4,000 impregnated salmon ova, which were hatched at the State establishment. About 3,000 of them succeeded, and when they had attained a proper age, a notice was published inviting anyone to apply for them who was willing to do so and who had any suitable stream or river where he desired to raise them. No answer was ever received at this office, and no application was made for them, which is a strong indorsement of the wisdom of the action of the commissioners in not spending money on an attempt which we were convinced must be futile.

For several years no salmon were reared in New York State, although 2,000 Kennebec River salmon were reported distributed in 1876 and 18,000 Maine landlocked salmon were reported planted in 1879. The stocking of Woodhull Lake in that year was successful in providing some salmon fishing. The report for 1883 stated that 350,000 eggs of Penobscot River salmon and 100,000 eggs of Maine landlocked salmon were received. New York was off on a salmon planting program of considerable magnitude.

Space here is too limited to permit a detailed presentation of the scope of the succeeding era of salmon planting. One point bears emphasis: this was primarily an action program, with efforts at research being limited to rather casual observations.

In 1944 a research program aimed specifically at the development of effective methods for increasing the number of landlocked salmon in New York lakes was started through legislative appropriation of $7,500. Unlike the rainbow and the brown trout, both of which established numerous breeding populations subsequent to initial stocking, salmon had failed to build up through natural reproduction in New York waters generally. Owing to shortage of egg supply, hatchery production had become very limited; and in view of many previous failures in stocking, there was little hope for success through merely expanding the propagation. Even though Salmo salar is a species that has been much studied, it was necessary to begin to study the species with relation to ecological conditions of New York waters, to determine the factors limiting survival, and to devise methods for controlling such limiting factors where possible.

Schroon Lake watershed was selected for the initial work because salmon were growing well and reproducing there even though in limited numbers. Also, the tributary streams afforded favorable conditions for experiments designed to test planting and other management methods. A weir was constructed for the purposes

of studying the salmon habits, trapping breeders for eggs needed for propagation, and decreasing population pressure of undesirable fish by stopping the upstream migration into areas suitable to support young salmon. Observations on experimental planting of fin-clipped yearling landlocked salmon above the weir in 1945 indicated encouraging results. The project was soon extended to include a similar study in Upper Saranac Lake and its principal inlet stream, where a weir was operated to trap salmon and decrease upstream migration of yellow perch into the areas planted with fingerling salmon. A number of planting experiments were undertaken in other waters, and experiments in tributaries of Lake George were started, utilizing Atlantic salmon.

Although the primary purpose of the project, as already stated, was research to develop methods, many of the stocking experiments were sufficiently extensive to result in a substantial increase in salmon angling. The project has been expanded and in its present form combines both research and management objectives. As rapidly as management methods can be developed on a test scale, these methods have been expanded. An increasing number of waters and management methods are being tested, resulting in some failures but frequently in a sound basis for expansion.

One of the most practical developments has been the demonstration that Atlantic salmon, from sea-run stocks, are adaptable to lakes. Because of a more abundant egg supply, these fish are being utilized more widely than so-called landlocked salmon (from fresh-water stocks). This has made possible a much heavier stocking program and the building of a salmon resource of angling importance in several waters, including Lake George (which is more than 28,000 acres in area). It was possible to take approximately 100,000 eggs from these fish during 1953 and again during 1954.

Unlike many studies of salmon, geared to units of resource of great magnitude, the New York study relates to a large number of individual lakes. In all these lakes, present or future salmon management must be considered in relation to the maintenance of recreational fisheries for other species, including lake trout, smallmouth bass, and others. Extensive rather than intensive research methods must be utilized. In many instances, inferences must be drawn from a few growth-rate samples or from other fragmentary data. Hence, studies have been streamlined to the bare essentials needed to give workable answers. In general, the steps have been to evaluate habitat conditions, carry on planting experiments by methods seemingly adapted to the situation, sample for survival and growth, and proceed from there either to discontinue, expand, or change methods. As tangible benefits, we can point to an increasing salmon resource, to an increasing interest in salmon angling, and to an increasing pace of stocking and other management efforts--with which it is to be hoped that an integrated program of research can somehow manage to keep up.

Since the invasion of the sea lamprey and the subsequent destruction of the lake trout, the problem of the "bloater" has arisen in Lake Michigan. A small cisco (chub) of almost no commercial value, the bloater was formerly a major item in the diet of the lake trout. As the inroads of the sea lamprey upon the lake trout population have decreased the predation of that species on the bloater, however, that fish has multiplied so rapidly that it is now competing with the more valuable chubs for space and food, as well as creating a nuisance by becoming entangled in large numbers in fishermen's nets.

WILL STUNTED BROOK TROUT GROW ?

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MANY STREAMS in Wyoming, because of overpopulation and insufficiency of required foods, are populated with stunted brook trout. The conception in the minds of many people has been that these stunted fish are incapable of any further growth. It is realized that this is no doubt true under the conditions of their mountain environment, but in the minds of fishery workers in Wyoming there has been some question as to whether this would be true if the fish were placed in an environment capable of furnishing conditions conducive to proper growth. Such factors as continuously low water temperatures, soft water, high populations, and below-average food conditions will naturally result in a reduced growth rate.

One of Wyoming's Fisheries Management Crews--made up of Fred Eiserman, John Mueller, Charles Sowards, and Louis Pechacek--was given the job of experimenting with this problem. Two streams, Doyle Creek and Middle Fork of Crazy Woman Creek in Johnson County, typical of the smaller high mountain streams which contain the type of brook trout mentioned, were chosen for the source of fish; and two reservoirs, Welty and Ramsbottom in Johnson County, known to have the conditions which would furnish the most suitable environment required, were chosen as the waters into which the fish were to be transplanted. Before being transplanted, the fish were fin-clipped or tagged for future identification. All transplants were made on November 4, 1953, and the fish were recaptured during the fishing season between May 15 and September 29 of the following year.

All of the fish taken showed an increase in growth and weight, with the average increase in length being 3.53 inches and the average increase in weight being 6.98 ounces. The greatest length increase achieved by any one fish was 7.63 inches; the least was 2.13 inches. The greatest weight increase made by any one fish was 12 ounces, and the least was 3 ounces. This is particularly notable because some of the growth was attained during the winter months, and their growth was fairly rapid because the average time in their new environment was 7.5 months. The greatest length increase made by an individual was made by a 2-year-old fish. Fish that were 3 years old had an average length increase of only 3.51 inches, and the 4-year-old group had an average increase of only 2.81 inches. Apparently the length of time spent in the stunted condition has some effect on the potential growth that may be expected from fish so transplanted.

One of the main differences in the waters of the reservoirs, as compared to the streams, was the greater alkalinity. This is considered the most important factor contributing to food production and the rapid growth of the transplanted fish. Food conditions in each of the reservoirs were noted to be above average; however, the supposition that the fish were not unalterably stunted was proved. Apparently fish populations found in this condition can be used to restock other waters, with full anticipation of beneficial results, provided that the transplanting can be done on a practical basis.

FISH HATCHERY SANITATION

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Montague State Fish Hatchery
Montague, Massachusetts

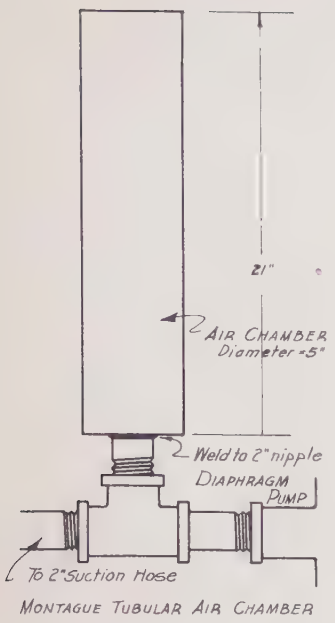
SANITATION may well be considered a major problem at any trout-cultural establishment where high production schedules are maintained annually. Certainly it is a factor in the all-important objective of producing large numbers of high-quality fish at reasonable cost for planting.

As labor may account for 40 to 60 cents of each dollar spent, and much of that sum is related to the system's sanitation, a closer look at the problem is advisable. At certain times fish culturists must spend hours cleaning from ponds the accumulated sludge or other matter that may affect the oxygen supply of the fish and thus cause their failure to convert the maximum of food to growth and weight. Despite recent advances -- better knowledge of foods, use of pellets, and better pond construction -- the sanitation problem remains.

At the Montague State Fish Hatchery we have devised our own equipment for handling this problem. One unit removes waste without disturbing the fish; a second cleans the larger ponds after the fish have been removed.

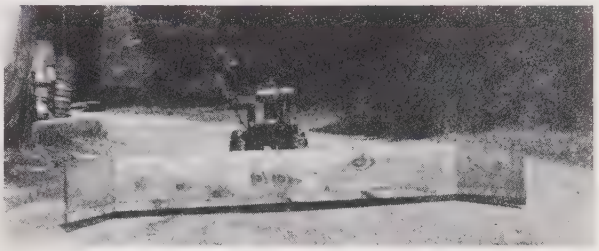
After trying all kinds of pumps, we chose a 3-inch diaphragm pump powered by a 3-horsepower air-cooled motor. The unit is mounted on 2 pneumatic 4.00 by 8-inch rubber tires. The size of the suction hose from the pump is reduced to 2 inches so the operator can maneuver the hose line more easily. The Montague pond-cleaning head is joined to the suction hose by 2-inch aluminum tubing, which makes it possible to go over the bottom of an ordinary pond in much the way one would clean the floors of a home. Aluminum is used between the cleaning head and hose line because of its weight, though copper tubing can be used with less trouble in attaching standard thread fittings. We use standard 3-inch suction hose for discharge in preference to any other, as discarded fire hose, for example, will usually cause obstruction in passing sand or gravel. Having no sewer drain, we haul the pump back of our 3/4-ton pickup truck, on which is mounted an obsolete distribution tank. The tank is equipped with baffles, an overflow at the front, and a bulkhead at the rear for quick discharge. The Montague tubular air chamber is installed between the pump and suction line to control pulsation trouble. As far as we know, all diaphragm pumps are made without this convenience. It is suggested that anyone building his own chamber should check the job expected of the pump -- as elevations and distances -- and know the minimum of area before trying to arrange something permanent. Also, the section of tubing should be of a length to correspond with the working depth of the pond system.

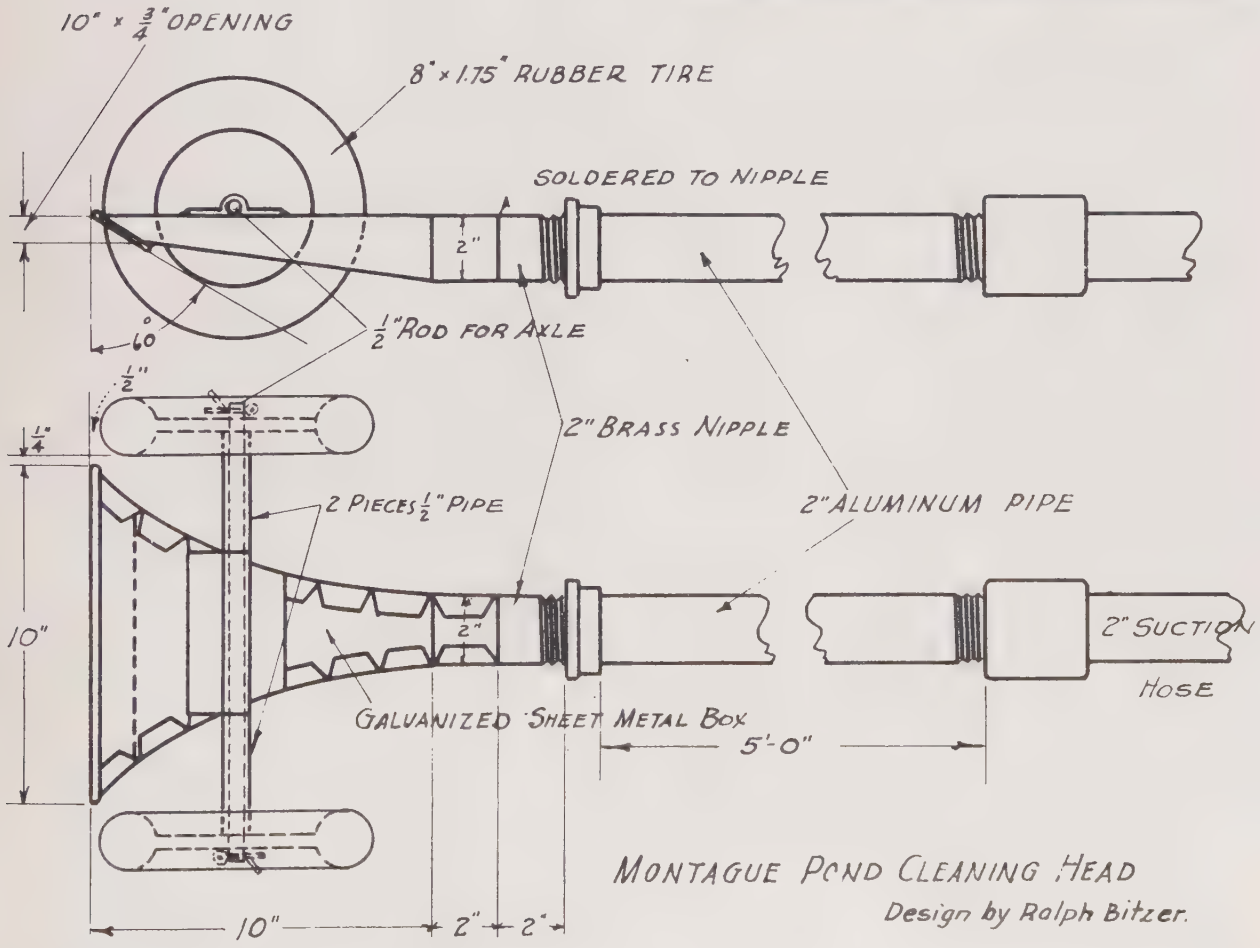
A second very efficient, labor-saving device used here is the mudplow, adapted particularly for cleaning larger ponds. The plow is powered by a tractor (2-1/2 horsepower) using 5.00 x 12-inch rubber-tired wheels fitted with tire chains. Better traction is secured with the larger wheels, and reverse gears are now obtainable on most garden tractors. We use the push column of our snowplow to attach the mudplow so that it can follow the contours of ponds. The plow is white pine, 12 feet long (including a 2-foot wing at an angle at both ends) and 14 inches high. The base is solid 1/2-inch rubber, 12 feet by 4 inches.



Montague Tubular Air Chamber

The lower section of frame has an offset so the rubber can be cased with a smooth or straight facing. Bolts used for casing, 8 inches apart, make it possible to reverse rubber as the sharp edges wear. The best results are obtained by not allowing rubber to extend more than 1-1/2 inches below frame.





MONTAGUE POND CLEANING HEAD

Design by Ralph Bitzer.

DIVIDENDS FROM RESEARCH

WHY BLAME THE CLAM DIGGER?

John B. Glude
U. S. Fish and Wildlife Service
Boothbay Harbor, Maine

Work of the Fish and Wildlife Service's Clam Investigations began during 1948, when soft-shell clams became scarce in New England, supposedly from overdigging. The word "investigation" implies fact-finding, so our research program was designed to provide the facts regarding the clam shortage.

Catch statistics indicated depletion of soft-shell clams in Massachusetts. Production had dropped from 8,400,000 pounds of meats in 1940 to 625,000 pounds in 1948. The number of diggers in Ipswich had dropped 90 percent. Our census showed few clams remaining in the flats.

What caused this shortage? Overdigging was blamed. Yet today, after 5 years during which only a negligible amount of digging occurred, the clams are still scarce. Seed clams which we planted disappeared in 3 weeks. Yet, if the plots were covered with 1-inch mesh chicken wire, the clams survived and grew well. Therefore, some natural enemy must have eaten the clams.

Further research disclosed three important predators: Polinices, the boring snail; Limulus, the horseshoe crab; and Carcinides, the green crab. The most serious predator north of Cape Cod proved to be the green crab, which is now tremendously abundant. Laboratory experiments showed that each green crab could devour 15 small clams in a day, which explained the failure of our unprotected clam farms.

Why should green crabs suddenly become a serious enemy of the soft clams? Records made before 1900 stated that green crabs occurred only south of Cape Cod. From 1905 to 1915 green crabs appeared in Casco Bay, Maine. From 1948 to 1953 they were present all along the coast of Maine and even in Canada. From all areas, diggers report that these crabs are now more plentiful than ever before in history.

The spread and increase of green crabs may be correlated with warm temperature trends. Average air temperature for the coldest month of winter has increased from 23.6° F. in the 1821-40 period to 28.4° F. in the 1941-52 period. This long-term increase in temperature may be responsible for the northward extension of the range of the green crab. Short-term warm cycles such as those from 1923 to 1933 and 1943 to 1953 are believed responsible for increased abundance of green crabs and the resulting scarcity of clams. Gulf of Maine water temperatures for the coldest month of the winter averaged 31.9° F. in 1943 but rose to 37.1° F. in 1952.

How can predators be controlled? Green crabs can be trapped easily, but they are so numerous that this method has not yet proved practicable. In one 12-acre cove we trapped more than 30,000 crabs in a month, catching more on the last day than on the first. Low screen fences with a horizontal strip of sheet metal at the top partly protected one clam farm. Chicken wire laid directly over the flats protected the clams but cost $2.75 for each bushel of clams produced. Control by poisoning and by finding enemies of the predators is being investigated, but

so far the best bet seems to be a series of cold winters.

SOME HANDY FORMULAE

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About 25 years ago our knowledge of the reproduction of oysters in Long Island Sound was rather limited and many of its aspects were covered by a veil of mystery. We do not know all the answers now, but we have learned so much since that time that it is amusing to recall certain ideas expressed by some of the old-timers.

The industry has always been interested in the time when the oysters begin to spawn and the time when "setting" occurs. The oysters "set" when the larvae descend to the bottom and become small oysters. This change, or metamorphosis, from the swimming to the sedentary stage is known as setting.

Each of the old-timers had his own unshakable opinion about the behavior of oysters, and it was unusual if two oystermen agreed on any subject. For example, some insisted that setting occurred only in August, others thought that it took place only during the third week of September, and still others--and this is a fact--maintained that some oysters spawn and set even in winter. Further, some oystermen said that all oysters of a new generation set on the same day all over the Sound, while other oystermen believed that there were two or three distinct sets--perhaps 6 weeks apart. Many other opinions were also supported vigorously.

To sum up, nobody knew much about the subject. Yet, the dates of the beginning of spawning and especially of setting were -- and still are -- of great practical importance to the industry, for by the latter date the oystermen should have the grounds fully prepared to receive the new generation of oysters. This preparation consists of cleaning the oyster beds and planting clean oyster shells (the cultch) to provide attachment for the descending oyster larvae. Some of the largest oyster companies of Long Island Sound plant as many as a million bushels of shells every year, and that quantity indicates that the planting is a rather extensive and expensive undertaking. Obviously, planting shells at the proper time is essential. If they are planted too late, they will miss the set. If they are planted too early, they may become fouled and become unsuitable for attachment of the larvae.

Systematic and persistent research of biologists eventually helped to clear up many mysteries. It is true that this meant many years of observations, most of them made on inadequately equipped small boats or skiffs with few or no helpers and, at first, with practically no laboratory facilities. However, the research paid, and several years ago we were able to offer the industry the following formulae:

> In Long Island Sound the beginning of spawning should be expected on June 30 $\pm$ 4 days, and the beginning of setting should be expected on July 19 $\pm$ 4 days.

These formulae have held up rather well thus far, and now the industry fully depends on them, admitting the practical help that research has given.

Many other data, such as the extent of the setting period, intensity of setting in relation to time and depth, and growth and survival of young oysters under different conditions, have given the oystermen much needed practical information since our studies began.

In the 1953-54 season, 18,580,813 anglers paid $38,927,735 for licenses for their sport.

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